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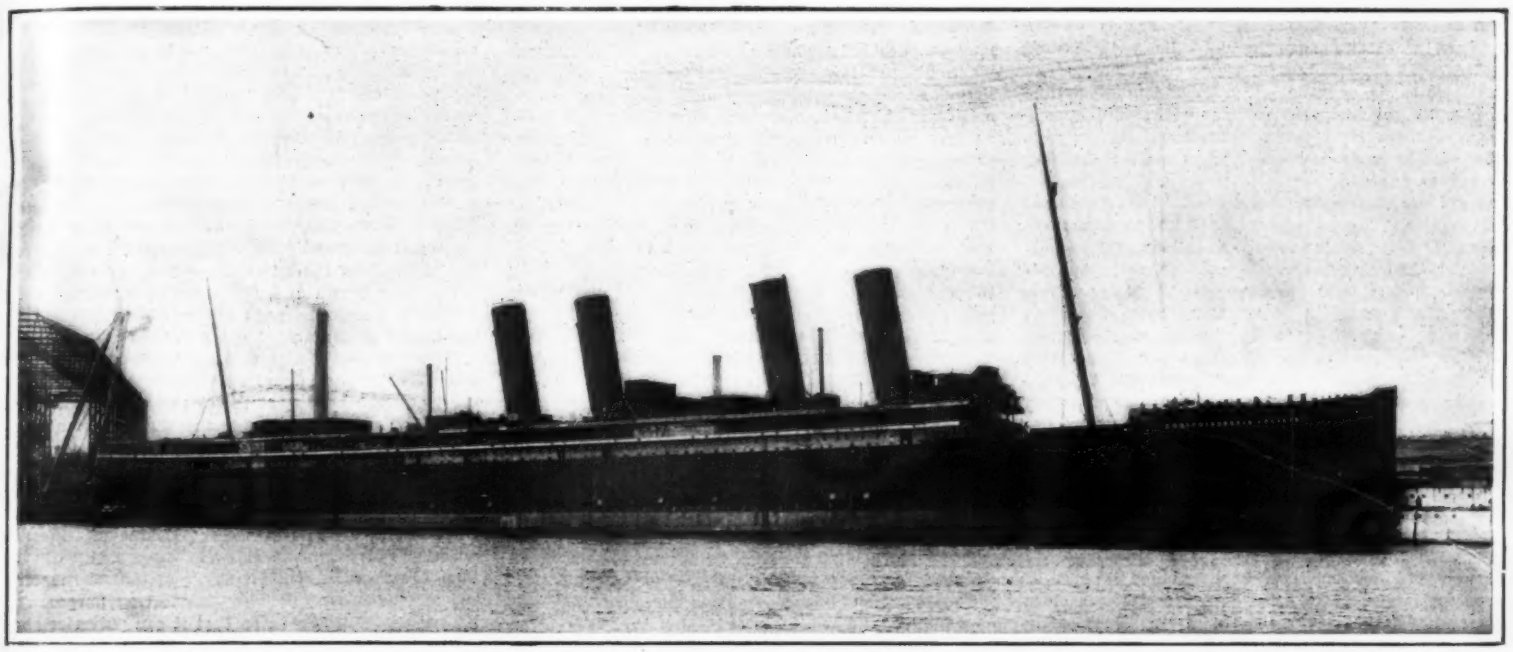


THE TRANSATLANTIC STEAMER "KRONPRINZESSIN CECILIE."

DINING ROOM FOR FIRST-CLASS PASSENGERS.

THE BUILDING OF A TRANSATLANTIC STEAMER.—[See page 344.]

MICA.*

THE DEPOSITS OF THE UNITED STATES.

BY DOUGLAS B. STERRETT.

Of the minerals composing the group called mica, practically only two are commercially valuable for their physical properties. These are muscovites, or potash mica, and phlogopite, or magnesia mica. The interesting properties of mica are its perfect cleavage and the toughness, flexibility, and elasticity of its cleavage sheets. These properties, combined with transparency and non-conductivity of electricity, render the varieties mentioned valuable in the industrial world.

Of these two varieties of mica, only one, muscovite, is found in deposits of commercial value in the United States. Muscovite occurs widely disseminated in small plates and crystals of no value in crystalline igneous and metamorphic rocks, as well as in the sediments derived from them. Commercially valuable muscovite, however, is confined to pegmatite. The latter is closely allied to granite in composition, but unlike granite, its constituent minerals are crystallized out in large masses, sometimes with an extremely coarse granitic texture, and at others in veinlike bands or irregular segregations. Among the coarser products of crystallization of pegmatite is mica, which is sometimes found in blocks more than a yard in diameter.

A large number of accessory minerals occur with mica and in pegmatite. Among the more common ones and those of commercial value are quartz, massive, crystallized, smoky, and rose; feldspar, potash, and others; kaolin; beryl; tourmaline gems; spodumene, kunzite, and hiddenite; sircon; lepidolite; cassiterite; uraninite or pitch blende, and other rare minerals. The mica crystals occupy various positions in pegmatite masses, and no positive rule can be made for finding them. Where the pegmatite has a typical granite texture the mica may be found evenly distributed through it. Often the larger crystals will be found either in clusters at intervals through the "vein," in places partly connected by streaks of small crystals, or along one or both walls of the pegmatite. Where there is a quartz streak within the pegmatite the mica occurs on either or both sides of it.

Deposits carrying mica of commercial size have been found in the United States in the following States: North Carolina, New Hampshire, Virginia, South Dakota, Colorado, New Mexico, Idaho, Arizona, Georgia, South Carolina, Alabama, California, Maine, Connecticut, New Jersey, Maryland, Wyoming, Nevada, and a few other States. In the first nine, and probably more, of the States mentioned there has been a production of mica at one time or another. Mica of commercial size has been found in many foreign countries, including Canada.

There is a wide variation in the methods used in mining mica, depending at times on the conditions of occurrence of the mica, and at other times on the location of the deposits, the cost of labor, and the ability of the individuals or companies to operate them. Where the mica deposits are somewhat regular in content, direction, and extent, it is possible to work them by systematic methods similar to those employed in mining for other minerals. Regular shafts, inclines, crosscuts, drifts, stopes, and winzes can be profitably employed, and power used for drills, hoisting, pumping, etc. Where the mica deposits are irregular in shape and extent, pinching and swelling from place to place, and are folded with the inclosing rocks or badly mashed and faulted, it is not possible to work them systematically.

The tendency in the past, prior to the last few years, has been to work all mica mines only for present values, with too little regard for future production. In this way the majority of the mines have been so opened that, after their value has been proved, it has been very costly to prepare them for extensive operation. Of course a deposit must be proved valuable before extensive work is undertaken. Too often the miner testing the deposit must have some returns for his labor, and accordingly he follows the mica wherever found, by pits, cross-cuts, inclines, shafts, and tunnels, irregularly spaced. Thus the mine is given a poor start, and the farther such work is carried the more difficult it becomes to begin systematic mining. Very often, however, when a mica deposit is irregular in shape the only feasible way of learning its extent is to follow the mica streak wherever it may lead, and accordingly systematic prospecting is not possible.

Mining in New Hampshire and the Western States has been carried on more systematically than much of that in North Carolina. In the latter State, however, the mica deposits are being more and more methodically opened and mined wherever possible. Unfortunately, there are a large number of deposits in this State which are of such irregular occurrence that it is impossible to use regular methods of development.

The methods employed in preparing sheet mica for the market do not differ greatly, even in widely separated localities. The usual operations, after the rough material has been obtained from the mines, are as follows: The rough crystals, weighing from a fraction of a pound to many pounds, are split with wedges and knives into sheets of suitable thickness for cutting into patterns. The rough edges are trimmed off with knives held at an angle to the cleavage plane while cutting, and harmful inclusions and other imperfections are removed. The next step consists in cutting the sheets into patterns of such size and shape as may be in demand. This operation requires considerable judgment, in order that there may be a minimum of loss by waste. Whereas formerly it was customary to have a "scriber" mark the outline of the pattern to be cut from each sheet, this is now almost entirely done by the man who does the cutting. The latter lays a templet of metal or composition on the sheet of mica, and after choosing the most favorable form and largest size possible, cuts around the edge of the templet with large shears. These shears have the lower blade stationary, while the upper one is generally operated by hand. Machine knives operated by power are in use, however, in the larger cutting establishments of Canada.

Considerable mica is punched into disks, washers, and other forms for electrical use. The chief demand is for sizes under 2 inches in diameter, though disks and rings are punched with a diameter of over 4 inches.

Less than half of the scrap mica produced in North Carolina is ground in that State.

The following is a general description of the type of grinding mill in use in Mitchell County, where the grinding is done locally: Both steam and water power, or a combination of the two when the water supply is insufficient, are employed. The mica is first shaken thoroughly in rocker washing tubs, by which the filth is removed. The grinding is accomplished by soft-wood beaters through which large spikes are driven with the ends projecting on all sides. These beaters have an elliptical cross section and are from 30 to 36 inches in diameter and from 6 to 10 inches thick. They revolve horizontally in large wooden tubs and are so arranged that they can slip up and down vertically with their shaft when they become clogged in any position by an excess of mica. The tub is of suitable size for the beater to revolve in and is from 30 to 36 inches high. The scrap mica is placed in the tub with water and the beater set in motion. As the latter revolves the steel spikes beat and tear the mica. It requires about twelve hours to grind a charge, which often becomes steaming hot toward the end of the operation. Water is added as needed. From the grinding tubs the mica, now in the form of a mush, is washed to settling vats, where, after eight to twelve hours, the water is decanted off. The mica mush is then spread on cloth-covered drying tables, beneath the surface of which heat is supplied by steam pipes or in other ways. After eight to ten hours the mica mush is dried and is removed from the tables on the cloth in the form of cakes or lumps. The latter are crushed and beaten apart in disintegrators or pulverizers, and the ground material is sized off in hoppers or screens by bolting through silk sizing mesh.

A charge consists of from 400 to 500 pounds of scrap, according to the size of the grinder. From three-fourths to four-fifths of this is returned from the sizing screens as over size and is placed in the grinder with the next charge. The beaters are run at from 250 to 300 revolutions per minute. At one mill it was said that a larger percentage of 160-mesh ground mica was obtained than of any one of the other sizes separated—that is, 10, 60, 80, or 100 mesh, the sizes commonly separated at the mills. Different sizes down to "bran mica" can be separated whenever ordered.

At one time in North Carolina scrap mica was ground with buhr-stones, which were revolved over a tub on which the stone rested. The ground mica was continually washed down into the tub and passed out through small holes in the side of the tub.

The utilization of scrap and waste mica in the manufacture of lubricants for car axles has become a somewhat important industry in the West. An extensive plant erected for the preparation of mica for this purpose in Denver, Colo., has been described by Mr. Fritz Cirkel as follows:

"The mica comes to the factory in carloads just as it is taken from the mine. It is fed by boys into two machines, which cut it into fragments about half an inch square. By a system of pneumatic tubes the mica so cut is delivered to the atomizing machines, which grind it into powder. Each machine consists of two steel shafts 3 feet long, with a series of spirally arranged beaters, of gun metal, which revolve in a close case. These machines make from 5,000 to 7,000 revolutions per minute. The fingers on one shaft run between the fingers on the other, so that when the material is passed through the pneumatic tubes from the feeding machine to the atomizers at a velocity of 15,000 feet a minute the work of atomizing is instantaneous.

"The mica, now reduced to minute particles, continues its course at the same velocity through another set of pneumatic tubes to the sizing bins. Here the current is so retarded by a special mechanism that it causes the material to settle, according to its fineness, in the various compartments, of which there are six. Compartments containing the graded mica powder rest upon hoppers or bins immediately over the mixing pans. Into the latter the several grades of mica powder are drawn and, by means of mechanical mixers, with which the pans are provided, treated with the proper percentage of oils and other ingredients.

"Directly over the hoppers are located the oil tanks, which supply the mixers by a pipe running down the outside of the hopper, at the end of which is a faucet.

"At one end of the bins is the 'dust arrester,' a cylindrical machine 4 feet in diameter and 10 feet high. Any of the material too light and fine to settle is driven into this machine by air currents and is drawn off as needed.

"It is stated that before this machine was invented no other pulverizing machine had a capacity of more than 300 or 400 pounds a day, and that the material was not sufficiently fine for lubricating purposes. It is claimed for this concern that it can pulverize about 5 tons in a day of ten hours and that it turns out an excellent lubricant."

The three principal uses of mica are for electrical insulation, glazing, and decoration. The first-named application probably leads in present importance, but the other two uses date back to ancient times, mica antedating glass, and also being early used to secure decorative effects.

As an insulating material, mica occupies a place that can not be filled by any other substance. Its toughness and elasticity have already been mentioned, but equally important characters are its infusibility and softness. In the majority of cases where mica is used for insulating purposes in electrical apparatus, the muscovite variety, or white mica, is as serviceable as the "amber" or phlogopite variety. Both kinds are used for building into large sheets of "micanite" or "mica board." For insulation between segments of commutators in dynamos and motors there are nothing superior to the Canadian phlogopite and certain varieties of India mica. The latter is of about equal hardness with the hard-drawn copper segments placed on each side of it in the commutator, and the whole wears down evenly, preventing sparking. Though muscovite is used for the same purpose, it does not give the same satisfaction as the phlogopite. For all electrical insulation the two varieties, when clear and pure, are extremely efficient. The insulating qualities of mica are, however, according to Mr. P. O. Maloney, greatly reduced by contact with oil. In some cases the power of sheet mica to withstand an insulation test under high potential currents was lessened by one-half when the plate was coated with paraffin oil.

Black-specked mica is much less capable of withstanding high-pressure currents, and accordingly finds less extensive use in the electrical industry. It is often stated that "specked" mica is valueless for electrical purposes. This is disproved, however, by the quantity of specked mica mined each year and sold to electrical dealers. It is claimed that the crystals of iron oxide, especially when of appreciable size, have a tendency to short circuit high potential currents through the mica. Several large mica-manufacturing firms, however, report that there is a good demand for speckled mica, since it costs only from one-half to two-thirds as much as the clear, and it can safely be used for all insulation purposes, other than for armatures, where the current is to be under 1,000 volts. One large company in North Carolina stated that its supply of this grade did not meet the demand, and that it did not encourage the use of specked mica, as there was more money in the better grades. Many large electrical manufacturers do not use specked mica, even in apparatus where it would be perfectly satisfactory, since they hear it condemned by many people and know that whenever there is trouble with any

* Abstracted from a bulletin issued by the U. S. Department of the Interior.

piece of apparatus the blame will be laid on the specked mica.

Where the specks are between the laminations and rarely of appreciable thickness, as in the North Carolina specked mica, they can sometimes be eliminated, entirely or in part, by splitting. Where low-potential currents are used, however, it is not necessary to remove the specks, since scarcely any thickness of the laminations is ever intersected by them.

The increasing use of mica in electrical manufactures has largely modified the demand made upon the mining industry. Small sizes of sheet mica can now be utilized in the manufacture of insulators in lamp sockets, lightning arresters, switch boxes, and fuse blocks. More important even is the extensive use that is made of composite mica, "micanite," "molded mica," and other varieties of built-up mica sheets. In the manufacture of material of this class thin laminæ of both regular and irregular form and of different sizes, according to the quality of "mica board" desired, are arranged and cemented together to form thick sheets of any size in demand. Not only can sheet mica of small size be thus utilized, but where there are other minerals included between the folia which might destroy the value of certain sheets these can be removed in the process of thin splitting. The mica board has largely supplanted the large-sized sheets of natural mica in the electrical industry, because of several advantages possessed by the built-up material. The lines of molecular weakness which give rise to the percussion and pressure figures in the natural sheets are avoided by the different orientation of the thin films constituting the composite sheet, with the result that strength is increased as well as the resistance to arc punctures. The use of shellac or other cementing material increases the flexibility of the mica during the process of manufacture, allowing the plates to be molded into a great variety of forms for use in electrical apparatus. Since this material was first introduced its application has been rapidly extended. To-day not only is it used in small sizes in the insulation of electrical apparatus and for covering the handles of electricians' tools, but its strength and resistance to moisture especially fit the molded mica for use in weather-proof lamp sockets and telegraph and feed-wire insulators.

The use of mica for stove windows formerly constituted the principal demand for sheet mica, but this has decreased somewhat in recent years. The increased use of sheet mica in incandescent gas lamps and for miners' lamps has kept up the demand for glazing grades, so that whatever comes into the market is readily bought. Sheet mica is also used to some extent for phonograph diaphragms, and in various small boxes and other novelties.

Scrap mica is utilized in the manufacture of a superior quality of boiler lagging, a mat of finely divided mica flakes furnishing a fireproof covering that has sufficient strength to be durable, not disintegrating like some other materials, and excelling asbestos and magnesia compounds as a nonconductor of heat. The superiority of the mica lagging appears to depend not only upon the low conductivity of the mineral itself, but especially upon the loose texture of the mica mat.

Ground mica is used in somewhat increased quantities, the coarser grades in mica bronzes and paints, and also as an absorbent for explosives. Ground mica also forms an ingredient in some heavy lubricants. The finest ground mica, or mica flour, finds a considerable market with the manufacturers of high-grade wall paper, the luster obtained by the use of the muscovite dust having the advantage of both permanency and brilliancy. Specked mica is seldom used for grinding where a good grade of ground mica is desired, since it spoils the color and quality of the latter.

The production of mica during 1906 in the United States came from eight States—North Carolina, Colorado, New Hampshire, Virginia, Idaho, South Dakota, New Mexico, and Connecticut—here named in the order of the value of their output.

The production of sheet mica amounted to 1,423,100 pounds, valued at $252,248, an increase of 498,225 pounds in quantity and of $91,516 in value over 1905. This increase is nearly all due to the growing production of North Carolina, which is credited with 800,440 pounds, valued at $205,756, while the aggregate production from the other States showed but little gain.

The total production of scrap mica in the United States in 1906 was 1,489 short tons, valued at $22,742, an increase of 363 tons in quantity and of $4,886 in value over 1905. Of this quantity North Carolina produced 1,129 tons, valued at $11,940, while the other States produced 360 tons, valued at $10,802. The much greater value placed on scrap mica in the other States as compared with North Carolina is due to their distance from the markets and to the high prices paid for scrap in the Western States, where freight charges on material from the East would be excessive. The value given for the North Carolina product represents the prices paid for scrap and waste mica at the points of production.

The mica industry in this country is expanding rapidly to meet the rapidly growing demand for the material. At present the effects of the increase are more felt in North Carolina than in any other State. New companies have formed, however, to operate in several other States—Virginia, South Carolina, Georgia, Alabama, and Colorado.

The imports of mica into the United States during 1906 were the largest ever recorded. The quantity of unmanufactured and trimmed mica entered for consumption was nearly twice as great as in 1905 and exceeded the previous largest imports, in 1902, by 814,882 pounds. The value of these imports in 1906 was considerably more than twice as great as in either 1902 or 1905, the years in which the values of the imports have hitherto been greatest.

The statistics of production and importation of sheet mica show a total consumption in the United States of 4,489,838 pounds in 1906, as against 2,519,445 pounds in 1905, an increase of about 78 per cent. When it is remembered that less than one-third of this quantity comes from the home production, it will be seen what a field there is for an extension of the industry in the United States. These figures can not be used for a close comparison, for the reason that to represent properly the home production of rough sheet mica there should be added to the production given more than a million pounds of waste from manufacturing sheet and punch mica, which are at present included under scrap mica. If this were done, the average value per pound of sheet mica would drop from 17.7 cents to less than 10 cents, as compared with 34 cents for imported mica. Even in this case, with the quantity of production and of imports approaching equality, a comparison would still be unfair, for the imported mica would be of larger size and of much greater value than the home production. The larger sizes and greater value of imported mica are due to the fact that no small sizes can be imported in competition with the home product, the tariff being 20 per cent *ad valorem*, plus 6 cents per pound for rough and 12 cents for manufactured mica.

It is very difficult to make a definite statement on the prices of sheet mica. An average taken from the quantity and value of the total production would be very misleading, as part of that represents the manufactured material and part the rough product, and, since the prices vary widely for different sizes, an average value would not be representative unless the proportion of various sizes of sheet were known. The prices realized in North Carolina mica have advanced considerably in the last few years and are much better than they were a decade ago.

The average prices per pound of sheet mica in 1906 as obtained for several States were as follows: North Carolina, 25.7 cents; Colorado, 25.2 cents; New Hampshire, 3.6 cents; Virginia, 2 cents; Idaho, 2.5 cents. The large discrepancies between these values are due to the fact that part, at least, of the North Carolina and the Colorado mica was manufactured or selected material, while the output of the other States was reported entirely for rough, unsorted mica.

The average price of scrap mica, as obtained from the table of production, is $15.27 per short ton, while the value in North Carolina is $10.57. Prices quoted by different producers in North Carolina range from less than $8 to more than $15 per ton. In the majority of cases, however, the price is given by the producer as $10 per ton. The average price of scrap mica for the rest of the country is $30.05. This high value is caused by the extreme prices current in the Western States.

The industry in this country, especially in the Eastern States, is prosperous. With increasing prices paid for mica more mines have been opened and new companies formed to develop and operate mica mines, and with the growing interest in the industry the production in 1907 should show a substantial increase over that of 1906.

WATER IN GRANITE.

THE very general belief that wells sunk in granite will get no water appears not unreasonable when we consider that granite is the hardest of rocks and that its surface outcrops are as a rule so free from pores or crevices through which water might circulate that the expectation of finding water by drilling would seem absurd. Within the last few years, however, the many successful wells drilled in crystalline rocks have effectively proved the erroneous character of the old opinion.

The conditions controlling occurrence of water in crystalline rocks have recently been studied by Frederick G. Clapp, of the U. S. Geological Survey, whose field of work has been Maine. Mr. Clapp's detailed report will be published in a few months. The following paragraphs summarize his results so far as they relate to waters in granite:

The crystalline rocks, such as granite, gneisses, schists, etc., like the sedimentary shales, limestones, and sandstones, carry water in their pores—the microscopic spaces between the grains of solid mineral matter; but while the sedimentary rocks may absorb several per cent of their volume in water—sandstones about 15 per cent, limestones 5 per cent, and shales 4 per cent—granites and other crystalline rocks rarely absorb water to more than one-half of 1 per cent of their volume, and the water in such rocks moves through the pores so slowly that it can never escape fast enough to be of value in wells. Fortunately, however, the crystalline rocks are traversed in various directions by many joints and crevices. An investigation of these joints shows two principal systems, one of which is nearly vertical and the other horizontal. The vertical joints, which may be hundreds of feet in length, while not at all regularly spaced, are usually 10 to 20 feet apart, trend in all directions, and may be inclined to the vertical at any angle up to 30 degrees. The distance between the horizontal or sheet joints, which approximately parallel the surface, varies from a few inches near the surface to many feet at a depth of several hundred feet below.

The nearly vertical joints serve as channels for the admission of water from the surface, while the sheet joints form reservoirs for its storage. As most of the joints are rather narrow, the amount of contained water is likely to be moderate, and the yield of wells in granite is seldom more than 10 gallons a minute, though some exceptional wells, puniped by steam, have yielded as much as 30 gallons a minute. Out of 72 successful wells in southern Maine only two yielded more than 50 gallons a minute.

The extreme irregularity of the joint systems makes the success of any well in granite a matter of chance. Records collected in southern Maine indicate that about 87 per cent of the wells drilled in granite supply water enough for ordinary domestic uses.

The depth to which drilling should be carried in granite has a maximum limit of about 200 feet below which the chances of success diminish rapidly. Mr. Clapp's records show that out of 47 wells reporting the principal water horizon, 17, or more than one-third, found it within 50 feet of the surface; 16 more, or over one-half of the remainder, reached it within 100 feet of the surface; 7, or exactly half the wells more than 100 feet deep, tapped their principal supply between 150 and 200 feet; and only 4 wells obtained it from lower depths.

Granite water, where not contaminated by surface drainage, is excellent for drinking and is probably satisfactory for all other uses ordinarily made of water.

As to the cost, which is necessarily an important factor in the sinking of wells, the price for drilling 6-inch wells in granite on the coast of Maine ranges from $4 to $6 a foot, the higher figure being the more common. The cost of drilling granite wells and blasting open wells in the same rock is in some sections of Maine the same for either type, $6 a foot. Its freedom from the great danger of pollution, common to all open wells, makes the drilled well in every case preferable.

THE WORLD'S GREATEST WEATHER BUREAU.

THE United States government spends $1,500,000 a year on its Weather Bureau, which is more money than all the governments of Europe combined spend for similar service. It has a staff of many hundred skilled experts and trained observers, who in all parts of the country are constantly on the watch to see what the heavens will bring forth.

Some time ago a skeptical insurance company determined to investigate the amount of propery saved in one year by the warnings of the Weather Bureau. It was a company of conservative men, whose estimate would be under rather than above the truth, but it was found that on an average the people of the United States saved every year $30,000,000 because of their weather service. As the people contribute $1,500,000 every year to its support, this means that they get annually a dividend of 2,000 per cent on the investment.

Realizing that the further development of our knowledge of storms and of weather generally depends in large measure upon a better understanding of the sun and its relation to the meteorology of the earth, Congress recently, on the recommendation of Secretary Wilson, gave the Weather Bureau a sum of money to found a meteorological solar observatory. The constant procession of storms that sweep across the United States makes our country a particularly good place to study the relation of sun and weather. The site chosen was an unnamed peak in the Blue Ridge, sixty-five miles from the national capital. The Weather Chief christened the peak by the fitting name of Mount Weather.

The plan of the Mount Weather Observatory is probably the most important ever undertaken for the advancement of meteorological science. The sun holds the key to the weather. The Weather Bureau will search for this key, and with it, we hope, unlock the mysteries of cyclones, of droughts, and of torrential floods, and thus foretell the years of plenty and of famine.—National Geographic Magazine.

PHOTOGRAPHIC SENSITIVENESS.

HOW PLATES ARE TESTED.

BY DR. ALFRED GRADENWITZ.

THE light sensitiveness of a given photographic emulsion, both as to speed and color correctness, is doubtless one of the most indispensable data to the scientific photographer, and many methods have been suggested for ascertaining it.

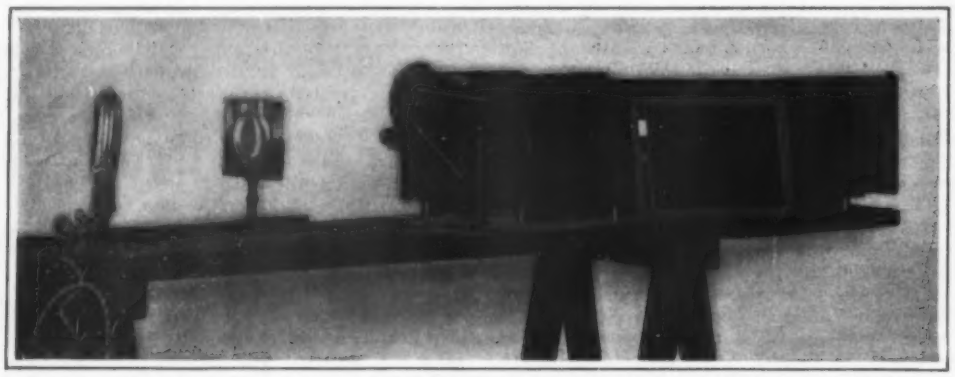


FIG. 1.—THE APPARATUS FOR DETERMINING THE SENSITIVENESS OF A PLATE, SHOWING THE LIGHT, COLOR FILTER, AND COLLIMATOR.

The only practical method of determining this sensitiveness for each region of the spectrum consists in photographing the spectrum itself. While the absolute intensity of a given region is apt to vary, the ratio between the luminosities of two regions will, in fact, in the normal spectrum, be strictly constant for all illuminants of the same kind.

This method is embodied in an apparatus designed by Ed. Belin, of Nancy, in which the sensitiveness of an orthochromatic plate is gaged by photographing a normal spectrum, illuminated with different intensities at different heights, the ratio between the amounts of light received by the various points of the same ordinate being accurately given, independently of either the photometric unit or the ordinate in question.

The apparatus, as represented in Figs. 1 and 2, consists of three parts, viz., 1, a standardized light source; 2, a spectrographic outfit; and 3, a shutter fitted in front of the collimator, and which will insure a constant ratio between the intensities of illumination of the various points of a given ordinate.

The light is a tube-shaped incandescent electric lamp fed by accumulators and mounted on a slide bar divided into half centimeters. This lamp would be advantageously replaced by a one-filament Nernst lamp, the filament being adjusted parallel to the collimator slot.

Between the lamp and spectroscope, a glass trough with parallel sides about one-half inch apart can be placed for receiving the colored liquids serving as light filters.

As regards the spectrographic apparatus, the use of a prism spectroscope obviously was out of the question, in order to safeguard the very principle of the method. In fact, the spectra obtained by the aid of such spectroscopes are bound to vary with the dispersive power of the refrangent medium. The diffraction or normal spectrum, in which the sines of deviation are strictly proportional to the wave lengths (dispersion being independent of the material the grating is made of) is alone fit for the present use. It is true to say that the normal spectrum shows an appearance quite different from prismatic spectra, and while the most refrangible portions are especially extensive in the latter, conditions are opposite in the normal spectrum. However, this peculiarity just proves an advantage in the present case, the regions of the yellow, orange, and red being particularly interesting from the point of view of observation. In the place of a concave Rowland grating, M. Belin uses a transmitted light grating fitted on a parallel quartz plate.

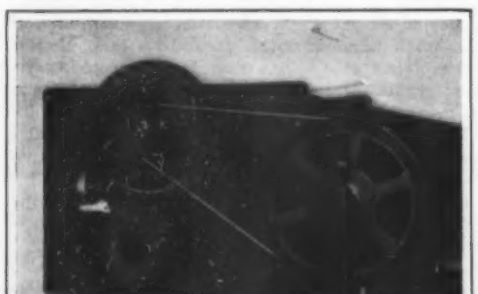


FIG. 2.—THE SHUTTER OF THE COLLIMATOR.

The shutter consists of a rather thin metal disk comprising two openings cut according to a special curve, which is based on the principle that the amount of silver reduced in a photographic plate is proportional, not to the absolute value of the ratio between the received and transmitted luminous intensities, but to the logarithm of this ratio. The divisions of the ordinates accordingly are proportional to the logarithms of the intensities of light received.

In using the apparatus, a rapid motion is imparted to the shutter, exposure varying according to the purpose of the experiment and the kind and distance of the illuminant.

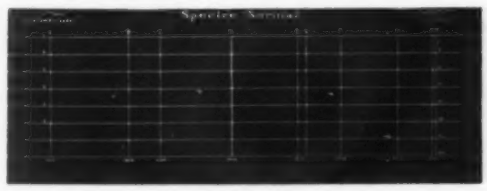


FIG. 3.—DIAGRAM OF THE SPECTRUM, TO BE PLACED ON THE PLATE AFTER EXPOSURE.

An accurate diagram, showing the principal subdivisions of the spectrum by the aid of Fraunhofer lines, should be traced on the plate after exposure, before the plate is developed, the total height of the spectrum being divided into seven sections, each of which corresponds to a given degree of sensitiveness, the illumination of each degree being half less than that of the preceding and twice stronger than that of the following degree (Fig. 3).

The curves shown in Figs. 4 and 5 both correspond to "orthochromatic" plates of high sensitiveness in the yellow and green, though the distribution of sensitiveness is strictly different in the two cases. In fact, the curve of Fig. 4 is characteristic of a plate having a general sensitiveness as considerable as ordinary plates, while being concentrated in another region of the spectrum. This plate can be used as orthochromatic plate without any screen. The plate characterized by Fig. 5, on the other hand, will require the use of a dark yellow screen, which is bound considerably to delay exposures.

The curves will incidentally allow different photographic illuminants to be compared with each other.

GAS ENGINE VALVES.*

By E. F. BLAIR.

THERE are three valves, as a rule, which are of considerable importance regarding the operation of a gas engine. In fact, the valves of a gas engine are such an important factor that the operator should make it his business to become perfectly familiar with every phase of their construction, condition, and operation. It is essential for the operator to know that his valve opens and closes at the proper time, and also that the valve is seating properly. The three valves are the fuel valve, the receiving valve, and the exhaust valve. The fuel valve admits the fuel to a current of air as it passes to the cylinder. The functions of the receiving valve are to open the air passages from the outside of the cylinder to the interior. The exhaust valve permits the burnt gases to escape from the cylinder after having spent the greater portion of their force against the piston. The fuel valve is made in two forms, a needle and poppet valve, which may be designed to open either by means of a positive cam or lever mechanism, or as the result of the suction of the piston. The other type may be only a needle opening and point, which leads to the seat of the receiving valve. If the valves are operated by means of lever and cam, it is necessary for the operator to know when they open and close properly, which can be determined by an occasional test to note whether the wear on the cam and the cam roller is having a detrimental effect on the correct action of the valve. The following is the proper method of testing a valve for the proper time of opening and closing, as well as the lift from its seat: First, revolve the flywheel in the direction in which the engine is running until the receiving valve cam just begins to open. Stop the engine and note the position of the piston. If the valve is operating in time, the piston should be just leaving the inner center and starting on its outward stroke. The valve is out of time if the piston is in a position considerably past the inner center, and indicates that the valve is opening too late. This may be due to natural wear, a wrong setting of the gear driving the cam, or a bent condition of the valve lever. To determine this, revolve the flywheel in the same direction as previously done until the valve seats itself or closes. The engine should be stopped just at the point where the cam releases the roller. If the piston is found to have reached the outer center, the valve has closed at the proper time. If the valve closes before the piston reaches the outer center, it has too early an action. If the valve opens too late and closes too early, it is good evidence that the cam roller and cam are badly worn, or that the valve lever is sprung. Should the valve open too late and close too late, or open too early and close too early, it is an evidence that the gear operating the cam is not properly set. The receiving valve should be open while the piston is making its complete forward stroke. In order to determine the lift of the valve, measure the length of the valve stem protruding from the valve chamber when the valve is seated, and again when it is lifted from its seat. Another trouble which affects the lift of the receiving valve is wearing into its seat. It is evident when this occurs to any great extent that the valve would have to lift just so much more in order to give the same result before the wearing occurred, as the wear is not automatically taken care of and the lift remains the same. It is evident that the valve opening is about ¼ inch less than it should be, hence it is seen that the outside measurement is not to be wholly depended upon. The exhaust valve will be found in a worn condition more frequently than either the fuel or receiving valve. This is doubtless due to the intense heat in which it continues to operate, thus causing it to work harder and wear faster. Under normal conditions the exhaust valve should open at about four-fifths of the working stroke of the piston, which is just before the piston reaches its outer center, and remain open until the piston has reversed and passed through the entire length of the exhaust stroke.

* Abstracted from the Engineers' Review.

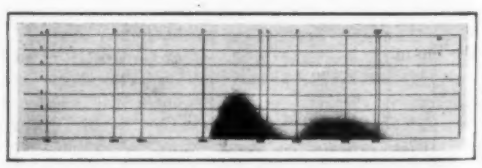


FIG 4.

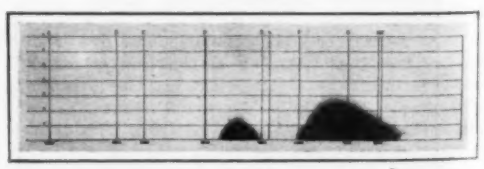


FIG. 5.—THE VARIATION IN ORTHOCHROMATIC PLATES, SHOWING THE NEED FOR SCIENTIFIC TEST.

This lets out the pressure within the cylinder and reduces it to nearly atmospheric pressure before the piston begins its actual exhaust stroke. Back pressure in a gas engine reduces the power of the engine, as back pressure in a steam engine affects its operation.

The tramcar that has been fitted by the Bradford Tramways Committee with the extensible axle commenced the permanent through service between Bradford and Leeds on Monday, September 23.

CONCENTRATING ORE BY OIL.

A DESCRIPTION OF THE ELMORE PROCESS.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

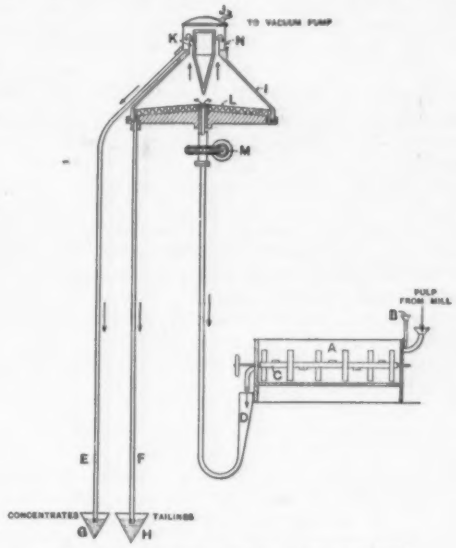
CONSIDERABLE interest is being manifested among Cornish tin-mining engineers and metallurgists in the new process for concentrating ores by oil, which is the invention of Mr. Alexander Elmore, of London. Owing to the crude methods followed in Cornwall for the extraction of the tin, a large quantity of material escapes in the tailings; and in all parts of the county may be seen huge mounds, the accumulations of centuries, which are composed of crushed ore from which the heavier particles of the tin have been secured. Metallurgists have, however, long pointed out the fact, as the result of their analyses, that these dumps still contain a fair percentage of mineral, and might be profitably exploited were a sufficiently efficient and inexpensive process evolved for the purpose. It was for this reason that the Elmore vacuum concentrator was installed, and the apparatus, which has now been in operation for several months, has achieved complete success.

The basis of this principle of concentration is the fact that in a flowing pulp of crushed ore and water oil when applied acts as a selective agent for the metallic substances as distinct from the rock and gangue, while, moreover, if such operation is carried out in a closed receptacle, wherein the pressure is somewhat below that of the atmosphere, the air or gases dissolved in the water are liberated either partially or entirely; and as these gas bubbles attach themselves to the greased mineral particles, in rising and expanding, they lift up the mineral particles with them, and float upon the surface of the liquid medium.

The process is simple in character, as is also the apparatus in which the operation is carried out. The accompanying illustration shows the concentrator itself, which is placed in the upper floor of the building, with the mixer below. The pulp flows from the mill into the mixer *A*, where are added small quantities of oil, and in some instances a small amount of acid, since thereby the selective action of the oil is sometimes appreciably increased. The contents of the mixer are kept in active agitation by the rotating blades *C*, and the assimilated pulp escapes through the funnel *D*, to which is connected the feed pipe to the concentrator. The latter is a conical vessel, which ranges from five feet upward internal diameter. At one side in the base of the chamber is the outlet *F*, for use in the escape of the tailings, while the metallic particles attached to the air and gas bubbles rise to the top of the chamber, overflow into an annular space *K*, from which they are carried away through *E*, the concentrates falling and gravitating through the water seal at the lower end of the pipe. At the base of the concentration chamber are placed rakes *L*, slowly rotated by the worm and wheel *M*, and the blades are placed at such an angle that the action of rotation causes the solid matter contained in the pulp to flow from the center to the periphery, whence it escapes in a constant stream through *F*, as already mentioned. A partial vacuum is set up within the chamber through the pipe *J*, so that, consequently, as pipes *E* and *F* are water-sealed, and while the admittance of air is impossible through the feed pipe *D*, owing to the presence of the pulp flowing from the mixer, the pulp is forced upward through the feed pipe, entering the chamber through the axis of the rake wheel. The inflow being faster than the outflow through *F*, the chamber is quickly filled, and just sufficient liquid overflows into the annular space *K* to carry off the metallic particles clinging to the gas bubbles through the pipe *E*. The feed pipe is generally from twenty-five to thirty feet in length, the tailings pipe being somewhat longer, so that they form the short and long legs of a siphon. Consequently, the power necessary to raise the pulp from the mixer through the feed pipe is supplied and governed by the falling column of pulp in the tailings pipe. Therefore, so long as a continuous flow is maintained from the mixer, a steady and entirely automatic discharge of tailings and concentrates must ensue through their respective outlets. The annular space *K* is glazed with heavy thick glass, so that the action of the separator and the discharge of the concentrates over the lip of the annular ring may be observed.

Owing to the slow speed of the revolving parts, this being from thirty to forty revolutions per minute in the case of the beaters in the mixer, and from one to two of the rakes in the separating chamber, vibration is entirely absent. The quantity of oil necessary to secure perfect selection varies according to the ore to be treated, but averages broadly from three to ten pounds per ton. The oil does not require special preliminary treatment, Californian crude, Texas crude, residuum, Borneo, blast-furnace, fish oil, and other similar low grades being equally efficient.

Although naturally the process cannot be claimed as efficient for the concentration of all ores, yet its field of application is very extensive, and it can be used with perfect success for those which from their peculiar characteristics cannot be concentrated by the general methods. Chalcopyrite can be readily separated

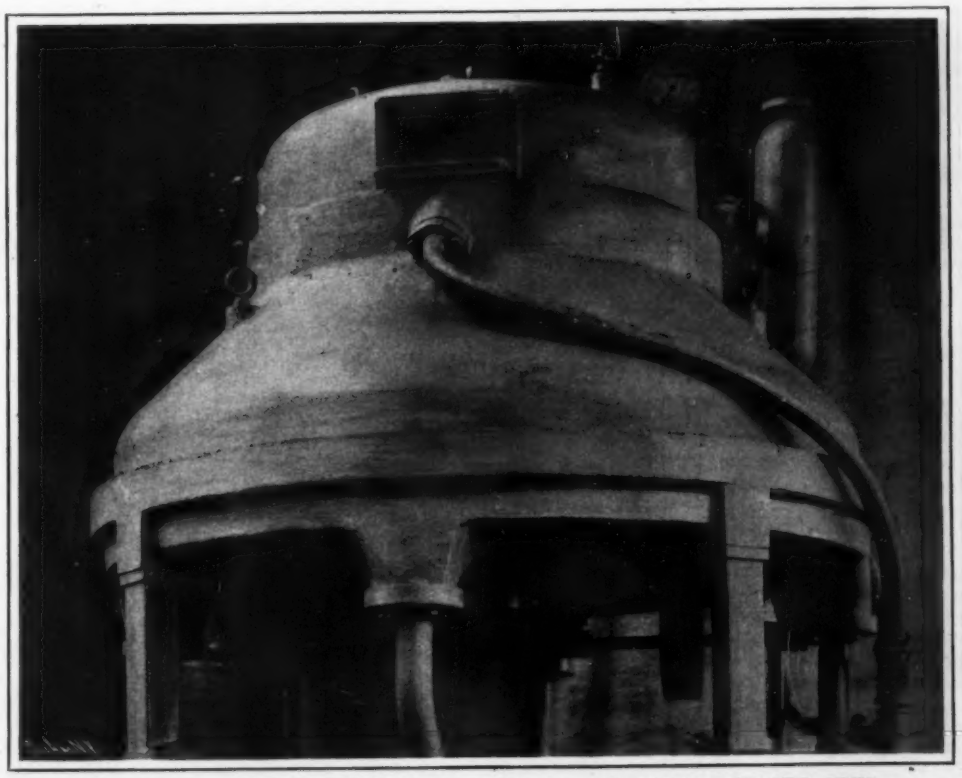


ORE CONCENTRATOR AND MIXER.

from magnetic and spathic iron gangue; galena and zinc blende from baryta gangue; copper sulphides from oxide tin, leaving the tin in the tailings for subsequent extraction by the usual methods; zinc, copper, and lead minerals from garnets and similar heavy gangues; while such minerals as antimony and molybdenum sulphides, which owing to their friable nature suffer such prohibitive losses in water concentration, can be separated readily by this process.

In Cornwall, where low-grade waste ores from the mine dumps are being treated in this manner, the average results are pulp 0.412 per cent, tailings 0.128 per cent, and copper concentrates 8.176 per cent. In the low-grade copper mines of Scandinavia excellent results have been obtained, the ores having a percentage of only 1.81 per cent of copper. After concentration the tailings contain only 0.037 per cent, while the concentrates comprise 6.83 per cent. Owing to the yield by this process being so much greater than that obtainable by other processes, this mine is now having a battery of eighteen machines installed. The capacity of the five-foot concentrator averages under normal conditions from thirty-five to forty-five tons of crude ore per twenty-four hours. The cost of operation is very small, a 2½-horse-power plant being ample for driving a 5-foot unit.

It is realized in mining circles that the process indicates a distinct advance upon the existing methods, and it has been recently installed at some of the copper and gold mines in South Africa and New South Wales, in each case being devoted to the concentration of the tailings discarded by the mines.



VACUUM OIL CONCENTRATOR FOR TREATING LOW-GRADE WASTE ORES.

INFUSORIAL EARTH WASTE.

THE employment of infusorial earths, in the manufacture of ultramarine, marked their introduction into industrial processes. For the purpose of producing an ultramarine rich in silica, infusorial earth was added to pure clay in the place of quartz sand. It is certain that it has become, in recent times, very popular for this purpose.

As a *heat insulator* infusorial earth has proved remarkably effective; in building ice houses, the space between the walls is filled with infusorial earth; in the same manner it constitutes an excellent filling for cash boxes, safes, and refrigerators.

As a polishing and cleansing medium for glass plates for photographic purposes, infusorial earth is to be especially recommended. Even greasy glass plates, cleansed with infusorial earth moistened with water, are rapidly made brilliant. Moreover, inasmuch as infusorial earth will absorb more than twice its weight of a fluid without deliquescing, by its aid where it appears necessary to employ acids, alkalies and similar solvents for cleansing purposes, it is possible to use them, to a certain extent, in a solid state.

In glass manufacturing, infusorial earth is exceedingly valuable, as it not only promotes the formation of the glass, but on account of its extraordinary division, mixes very readily with the remaining materials. In the same manner it is an excellent polishing medium for hollow glassware.

In the preparation of water-glass, we dissolve 74.5 parts of calcined soda in five times the volume of boiling water and keep the fluid boiling, after the addition of 42.5 parts of burned lime, previously slaked with water, until a small portion of the clear fluid, mixed with an acid, no longer effervesces. After the lime has settled, the clear fluid is drawn off by means of a siphon, the lime again boiled out with water, both fluids put together and the whole evaporated until it has a specific gravity of 1.15. Into this boiling lye, 120 parts of finely pulverized infusorial earth are gradually introduced. After this has dissolved lime water is added. This produces a brown deposit with the organic substances, which are mingled with the infusorial earth. The fluid poured off the precipitate, after it has been evaporated to a syrupy consistency, assumes the appearance of a pale yellow-colored jelly, which dries completely when exposed

to the air and readily redissolves in hot water. 120 parts of infusorial earth yields 240 to 250 parts of jelly, which contains 47 parts of anhydrous silicate of soda and 53 parts of water.

Infusorial earth is also employed for the production of light bricks or stones. 24 parts of Lüneburg infusorial earth, with one part of unctuous clay, furnishes a mass that is easily worked. But here a few difficulties are encountered. The infusorial earth, on account of its deficiency in binding capacity, requires the addition of binding clay, with which the finely pulverulent material can be mixed only by the most careful washing in. Furthermore, for burning it requires the temperature of a porcelain kiln.—"Verwertung von Abfallstoffen Aller Art."

THE DEVELOPMENT OF ARMORED WAR VESSELS.—XIV.

ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

Concluded from Supplement No. 1664, page 334.

MODERN AMERICAN ARMOR.

BEFORE the creation of the second Advisory Board of the Navy Department in 1882, a committee of Congress began an investigation on the reconstruction of the navy, and they went very thoroughly into the subject of the capacity of our iron and steel rolling mills to produce the material for the construction of the proposed new naval vessels, in which they were aided by the manufacturers placing valuable data in their possession of their ability to produce all the material to build vessels of domestic manufacture. Another committee of Congress was appointed in 1884 to investigate whether there were any steel mills in this country fitted to manufacture modern ordnance and armor plating. This committee went very exhaustively into the subject. There appears from the following copies of letters to the committee and others that there were some steel manufacturers in this country at the time who believed they were able to produce armor plating as required for the proposed armored vessels.

The Bethlehem Iron Company in November, 1885, said they had "made all needful preliminary arrangements for establishing suitable works for producing such material. We would consider a five years' contract, of not less than 6,000 tons per annum, at fairly remunerative figures, as necessary to justify our making the expenditure."

Benjamin Atha & Co., of Newark, N. J.: "We desire to indicate our willingness to undertake the supply of armor plate, and probably other ordnance material, if a suitable and positive contract can be entered into with the government for a quantity large enough to justify additions to our plant."

Moorhead & Co.: "We are prepared to furnish immediately, or within one month from receipt of order, plates wholly of charcoal hammered bloom iron, or of combined iron and steel, or of steel homogeneous in character, or of combined hard and soft steel, as may be required, say up to 7½ feet in width and 12 inches in thickness, and in weight up to 30,000 pounds each. . . . We furnished plates of iron to the U. S. Engineers' Department during 1866, '67, '68, and '69 of 6 inches, 7 inches, 8 inches, and 12 inches in thickness which were used for experimental casemate targets. . . . When the time arrives in which you will require armor plate, we will be very glad to submit our proposition as to price."

The report of this committee made in 1885 says of armor plating: "The present capacity of the United States to produce armor is lower than its power to obtain guns, since some encouragement has been given to the latter, and but little, if any, to the former. That several firms are willing to undertake the making of the armor up to any required thickness, providing the price paid is sufficient. What the price is, the majority of the firms is silent on; one of the largest of its kind in the country being willing to contract to furnish 12½-inch armor for a sufficient price, but could not name any definite figure for it."

It was understood at the time that some of the manufacturers would make a contract for a period of not less than five years, and to furnish six thousand to eight thousand tons of armor each year, for $500 a ton.

It is thus apparent that the subject of armor plating and gun forgings of domestic manufacture had been most thoroughly inquired into by Congress by the latter part of the year 1885, so that a few months after Mr. Whitney was appointed Secretary of the Navy, there were all the data necessary to take the first steps to have gun forgings and armor plating made in this country.

Just after the passage of the Act of Congress of August 3, 1886, authorizing the construction of the two armored vessels, the "Maine" and the "Texas," the Navy Department consolidated in one advertisement on August 26 following: "All its requirements for armor and gun steel for ships of war then authorized"; stipulating that it should be of domestic manufacture, and giving an average of two and one-half years in which to produce and deliver it, which covered the time necessary for the equipment of a plant. A period of about seven months was allowed for the submission of bids, in order to afford an opportunity for full investigation by expected bidders. The department also opened correspondence upon the subject with the principal steel manufacturers of the country. The interest awakened by the discussion and investigations already had, was stimulated somewhat by the influence of the department. The efforts of the department were generously seconded by the naval appropriation committees of the two houses, the sum of $4,000,000 having been inserted in the appropriation acts for the purpose indicated.

The bids for the gun forgings and steel armor were opened on March 22, 1887, and the only bidders for the armor plate were the Bethlehem Iron Company, of Bethlehem, Pa., and the Cleveland Rolling Mill Company, of Cleveland, Ohio, the former also bidding for the gun forgings. In the advertisement it was required of the contractor for the armor plate to provide within two and one-half years a plant capable of rolling 300 tons finished plate per month, and to deliver all of the armor within two years of that time. The Bethlehem Iron Company accompanied their bid with a statement in regard to armor: "It has contracted with one of the largest and most successful concerns in Europe engaged in making steel armor plates for the necessary aid, superintendence, use of patents, and guarantee of its work, and has arranged for a hammer of the largest class, if that be deemed necessary for the successful prosecution and completion of the work required for the government. . . . The company up to this time has expended in cash on the forging plant alone between $300,000 and $400,000, and is under contract obligations to the extent of $500,000 additional for machinery and tools to be delivered within the current year. The amount required to complete the plants for both guns and armor plate will be in all about $1,500,000, and for this the financial arrangements are completed." The award was made to the Bethlehem Iron Company for the armor plating and gun forgings, and the contract made June 1, 1887. The estimated amount of armor contracted for was about 6,700 tons, at an average price of $536 per ton of 2,240 pounds. This armor was to be of plain steel, oil tempered, and annealed, similar to that made at the Le Creuzot Works in France.

It may be as well to state that the first trial in this country of a modern armor plate was made just at this time. The record does not give the dimensions of the plate, nor the results. The armor seems to have been composed of two thicknesses of 1½-inch steel plates of different tempers, made by Joseph Illingworth of Newark, N. J.

The Bethlehem Iron Company was originally chartered in 1857 as the Saucona Iron Company, but in 1859 the name was changed to Bethlehem Rolling Mills and Iron Company. Their rolling mills commenced operations in 1863, and they began making steel rails in October, 1873. The Cleveland Rolling Mill Company was a Bessemer steel works built in 1867-'8, that had at this time an annual capacity of 100,000 tons of rails. They also had a large mill for making heavy steel plates, boiler and tank iron.

There now elapsed over two years before the Bethlehem Iron Company were able to begin operations on their contract, for it was in November, 1889, when they were prepared to begin work on the gun forgings, and September, 1890, before they were ready to produce the first light-weight armor plate; but it was not until the spring of 1891 that they were able to produce the first experimental armor plate for trial at Annapolis proving ground. But a small amount of this armor was furnished, as the trials with nickel-steel armor plates at Annapolis, Md., that were made at just this time, showed such superior merit and positive resistance under trials, that the making of the armor under the old specifications was stopped, and the use of nickel and the face-hardening process was adopted, called Harveyizing from the name of the inventor, H. A. Harvey, after a series of careful experimenting by the Navy Department that covered a period of about three years. In 1891 a board on armor-plate trials was appointed by the Navy Department, and in December of that year it made a report, in which the Harveyized plates of nickel-steel received first consideration, from their behavior during the several trials.

The Bethlehem Iron Company were still further delayed in the completion of their armor plant, for early in 1891 their two hydraulic forging presses had just been completely fitted in place, and the 125-ton steam hammer plant was well advanced in its erection in place; but it was not until the fall of that year that they were in a condition to make the heavier armor plate of the improved type. This armor plant was constructed in its general features after that of Henri Schneider & Co. at Le Creuzot, France, and the main parts were made at the works of Joseph Whitworth & Co. at Manchester, England, while some of the parts were of American design and manufacture. This steam hammer was the largest at that period, the next in size being the one of 80 tons at the Le Creuzot Works.

Carnegie, Phipps & Co., Ltd., were the successors of the Pittsburg Bessemer Steel Company, Ltd., proprietors of the Homestead Steel Works at Pittsburg, Pa. This plant was constructed in 1880, and their first steel rails were rolled in August, 1881. Early in 1888 they began making experiments on armor plate, and in the same year began the construction of a mill for slabbing heavy ingots and making armor plate. This plant was finished ready for operation early the next year, and in the month of March two experimental plates of three inches in thickness were finished for the protective deck of the armored cruiser then building at Philadelphia, Pa. The making of heavier armor began here in 1891.

The inventor of the Harvey Process, H. A. Harvey, had been prior to 1860 connected with the Harvey Iron and Steel Company, then located at Mott Haven, N. Y., of which his father was the manager. He was subsequently largely interested in several screw-manufacturing companies, and obtained several patents in this country upon improvements in the manufacture of screws. The face hardening of steel plates appears to date from experiments begun about 1880, where he had the idea of producing bolts and nuts of cast iron, with threads partially impressed upon them in the mold, and then hardening the surfaces to give them the toughness. This was at the time when the use of steel for structural purposes was receiving serious attention from designers and constructors of elevated railroads, bridges, and steam vessels. He continued at periods, with experiments along the line of a more perfect and uniform high grade of steel, and by 1885 he succeeded in producing a steel that was available for the manufacture of the finest tools and cutlery from a low grade of steel. The Harvey Steel Company was organized in November, 1886, and in 1889 a crucible steel works was erected at Newark, N. J., having five heating furnaces, three hammers, two four-pot steel-melting holes, and fourteen treating furnaces, for the production of finished forms and forgings. In this year the attention of the Navy Department was called to a description of the Harvey process as applied to engravers' plates. They had this process tried on some steel gun fittings, and on some small-caliber armor-piercing shell, and it met with a fair amount of success. It was then decided to apply this process to armor plating. The first experiment was not a success as far as the successful treatment of the plate was concerned. This plate, made by the Linden Steel Company, was 6 inches thick, and was tested in June, 1890. The Navy Department took much interest in these early trials of the improved process of treatment, for it was yet in an experimental stage. It was no doubt through the suggestions and advice of the department officials at different periods, given to the inventor, that this process at last became a success.

The first nickel-steel plate was made at the Le Creuzot Works some time in 1888, and Henri Schneider obtained a patent on nickel steel in this country, No. 415,655, on December 3, 1888. The first plate of foreign manufacture that was used in the United States was that tried at Annapolis in September, 1890. This metal, nickel, had been the subject of some experiments in 1880 by French specialists, "as possessing

many properties that deserve attention from those engaged in industrial pursuits. For example, it is not liable to oxidation by atmospheric influence, nor under any ordinary circumstances. It is more infusible, malleable, and ductile than iron. These qualities, however, cannot be utilized because it must be employed pure, and under special conditions. If one-thousandth part of magnesium is thrown into the nickel at the moment of fusion, then the metal will possess all the malleability that can be desired. It may be drawn, rolled, or welded in any manner in which iron can be worked."

The Navy Department determined after the test of the nickel-steel plate treated by the Harvey process, to have a more important test made to determine more fully the respective values of the compound plate, the plain steel, and nickel-steel plate, which was made at Annapolis, Md., in September, 1890. These plates were each 8 feet by 6 feet by 10½ inches. The compound plate was made by Cammell & Co., of England, while the plain steel plate and the nickel-steel plate were made by H. Schneider & Co. of France. The result of this experiment clearly demonstrated the superiority of the nickel-steel plate, for it fully resisted every shot striking its face, while the all-steel plate was cracked, and the compound plate was practically destroyed. All these plates, it will be noticed, were of foreign manufacture, for the Bethlehem Iron Company were not yet ready to operate their mill for production of the heavy armor plate.

To further test the nickel steel as treated by the Harvey process, a plate was obtained from H. Schneider & Co. of 10½ inches in thickness, and treated at the Washington navy yard under the inventors' instructions. It was very imperfectly treated, for the want of proper facilities for the treatment of such a size plate. It was subjected to a test in February, 1891, and showed the same general good results in the trial as the former nickel-steel plate.

The Navy Department now proposed to make further and more extended experiments, this time with plates of domestic manufacture, as the armor plants of the Bethlehem Company and the Carnegie Company were getting into shape for making the heavier armor plate. During the summer each of the companies produced experimental plates. These six plates were each 6 feet by 8 feet by 10½ inches. This test was to determine the relative resistance of high-carbon nickel steel, low-carbon nickel steel, and low-carbon nickel steel—Harvey treated. The latter plate showed most remarkable results, and demonstrated that it was a better type of armor than could have been purchased from any foreign manufacturer. There were further experiments made during the year, and so well had all the trials proved the Harvey process to be a marked advance in the treatment of armor plate, that early in 1893 the first contract for Harvey process armor was made by the Navy Department.

There was one experiment made that probably showed the merit of the Harvey process more than any of the other early trials, and that was the one made in May, 1891, a few months after the single Harveyized plate was tried at Indian Head proving ground, where there were five plates made at the Carnegie Steel Company works, each 3 feet high, 6 feet wide, and 3 inches thick, of the kind used for the protective deck of the unarmored cruisers. There were twenty-one shots fired from a 6-pounder Hotchkiss rapid-fire gun at each plate, firing forged-steel armor-piercing projectiles. The untreated steel plate stood the test the poorest of the sample plates. The untreated nickel steel of low carbon showed more resistance, while the untreated nickel steel of higher carbon showed a still increased power of resistance. The nickel steel treated by the Harvey process was practically uninjured at the end of the twenty-first round of firing. A further trial was made in September following, when a 3-inch all-steel plate and a 3-inch nickel steel plate, Harveyized, were tried, and 6-inch armor-piercing projectiles were used, wrecking the whole structure of the all-steel plate, but leaving the Harvey nickel-steel plate comparatively uninjured.

The Navy Department had now decided on the adoption of the Harvey treated nickel-steel armor for the armored vessels, and in 1893 contracts were made with the Bethlehem Iron Company and the Carnegie Steel Company for several thousand tons of this armor plate, and at about the same price as was paid for the plain steel armor, the government supplying the nickel and paying an additional amount for the Harvey treatment of the armor. This became the standard type of armor used by the Navy Department until the Krupp process of manufacturing armor plate, an improvement upon the Harvey treatment, was found by trials in 1898 to be superior in resistance to the latter, and the government shortly adopted its use, and have since used both the Harvey process armor as well as that made under the Krupp process. The remodeled monitors, as well as the seacoast monitors built in the last ten years, have been armored with the Harvey nickel-steel armor.

The Krupp process armor was first experimentally made in this country by the Carnegie Steel Company in June, 1898, but it was not until the spring of 1901 that they began to manufacture the armor for the Russian naval vessels then building in this country. The Secretary of the Navy had just prior to this made contracts with the Carnegie Steel Company and the Bethlehem Iron Company for the Krupp process armor for the three battleships of the "Maine" class then under construction, and it was on these vessels that the first Krupp armor was used in our navy. It is perhaps not too extravagant to say that the armor of to-day has a greater power of resistance to penetration than the armor used fifteen years ago, for plates of the same thickness, by 40 per cent; the Harveyized nickel steel being greater than the all-steel plates by about 15 per cent, and the Krupp process plates by 25 per cent greater than the Harveyized nickel-steel plates.

In 1897 Congress began a discussion on the question of the price of armor furnished to the Navy Department, brought about by the Bethlehem Iron Company having contracted in 1894 to furnish the Russian government with 1,500 tons of nickel-steel armor at the extremely low price of $249 per ton, made so by the active competition of the European armor manufacturers, who were decidedly adverse to the American armor manufacturers entering the foreign field with their product. Then ensued a long and bitter contest between the armor manufacturers and Congress over the price of armor plate to be furnished for several battleships then building in this country for the United States navy, and it was so acute at one stage that a board of naval officers was appointed to inquire into the cost of the making of armor plate, and also the construction and fitting with tools and machinery a government armor plant for the making of armor plate for the vessels of the United States navy; but the Secretary of the Navy in 1900 made a contract for the necessary armor at $420 per ton, that was a considerable advance on the price set a few years before by Congress for the making of the armor.

Mr. James M. Swank, of the American Iron and Steel Association, who is an authority on the manufacture of iron and steel in this country, in his "History of the Manufacture of Armor Plate for the United States Navy," says of this Russian contract: "The extremely low price of $249 per ton, at which the Bethlehem Iron Company contracted in December, 1894, to furnish the Russian government with about 1,500 tons nickel-steel armor, of which only about one-third was Harveyized, and which was mainly of very plain and easily-made shapes, was one cause of bringing the question of the price of armor to the attention of Congress, and has led many persons to feel that our government should be able to purchase its material from home manufacturers at an equally low price. Plausible as this contention may appear, a fair consideration of the facts will justify the action of the Bethlehem Iron Company. The great improvement in armor made in the United States by the introduction of nickel, and continued by the application of the Harvey process, was well known to the Russian government, and made it desirous of putting American-made armor on its ships. When the invitation to bid on armor plates was received from Russia in December, 1894, work on pending contracts with the United States was rapidly drawing to an end, and there was no prospect of receiving other orders from that source until additional ships should be authorized by Congress. Thus the Bethlehem Iron Company was about to suffer grievously by being compelled to shut down its armor plant because of the course pursued by the government in establishing a second plant, and dividing its orders, whereby neither plant could be kept steadily employed. Under these circumstances it was extremely desirable to obtain outside work in order to employ and keep together specially trained labor, and to prevent the demoralization of plant and organization. The situation was one with which every business man and manufacturer is familiar, that under the circumstances it was better to take the work, even if at a loss, without reference to fixed charges, than to have no work at all. In addition to this, it was recognized that a placing of an order for armor by Russia with a United States concern in competition with all the European manufacturers would be a notable event in the rapid march of the steel industry in this country, and would be the best possible method of heralding to the world that, though young in the business, the United States manufacturers had mastered the art and were ready to compete with all the world for the supply of armor plates of the highest quality." The Russian government subsequently made contracts with the Carnegie Steel Company and with the Bethlehem Steel Company for the higher grade armor at a very much higher price per ton than the armor furnished under the original contract.

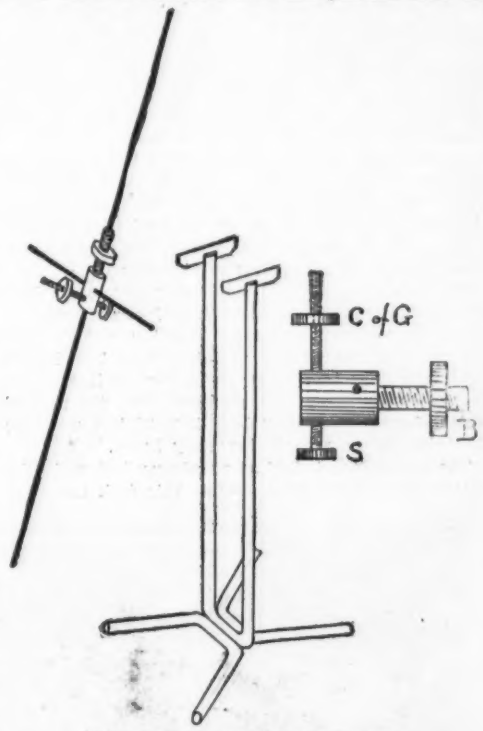
The Carnegie Steel Company and the Bethlehem Steel Company had the monopoly of the manufacture of armor plate for the United States Navy Department for several years on account of their extensive plants for the production of that commodity; but in October, 1903, the Midvale Steel Company, of Philadelphia, Pa., offered a bid for the armor proposed for the battleships "Vermont," "Minnesota," "Kansas," "Mississippi," and "Idaho," in competition with the Carnegie Steel Company and the Bethlehem Steel Company, and at a reduction in price on an average of about 5 per cent. They were awarded a contract for about one-third of the armor called for by the Navy Department. The Midvale Steel Company at this time had a plant that was not thoroughly equipped for the making of such heavy work as that bid for, but their proposal stated that they would be prepared in twenty months from date of contract, with all the machinery and tools to begin the delivery of the armor plate as required under the contract, and later events confirmed their proposal. On account of the faithful performance of their contract thus far, and their delivery of the armor up to the requirements of the Navy Department, they were awarded a second contract on April 5, 1905, for a limited quantity at a slight reduction in price per ton from that offered by the other bidders. They have been making deliveries under their contracts since then that have been satisfactory.

The prospect for a demand of armor plate by the Navy Department is not very bright at present, as the armor for all the armored vessels under construction has been under contract, and a large amount of this has been delivered, so that the two battleships for which appropriations were made during the session of Congress of 1904-1905 is all there will be a demand for from the Navy Department in the immediate future. The proposals for this armor plate were opened in July last, and there was a further reduction in price per ton by all the bidders, though the Midvale Steel Company made a greater reduction in price than the other two companies. For business reasons, the Secretary of the Navy awarded all the bidders a portion of the contract at the figures submitted by the Midvale Steel Company.

APPARATUS FOR DIP-NEEDLE DEMONSTRATION.*

By WILLARD R. PYLE.

IN preparing for a dip-needle demonstration it usually takes considerable time and patience after balancing the knitting needle to make the further adjustments needed for great sensibility. This piece of apparatus reduces the difficulty almost to nothing.



APPARATUS FOR DIP-NEEDLE DEMONSTRATION.

The support is of ¼-inch brass rod, and it stands 6½ inches high. Pieces of 1/32-inch sheet brass are sweated into slits at the top, the upper edges of the pieces of brass having first been taken down to perfect smoothness on an oil stone. The distance between these supporting edges is 1⅝ inches. The needle-holder is 5/16 inch in diameter, and has a total length of ⅞ inch. The axis is made of a short piece of No. 16 knitting needle, sweated into a hole bored slightly above the one through which the unmagnetized needle passes. (This axis should always be vaselined to prevent rust when the apparatus is put away.) *S* is a set-screw, *B* is a nut for balancing the needle, while *C of G* is used to raise the center of gravity as close to the axis as may be required for any desired degree of sensibility. Usually a slight adjustment of *B* is necessary after moving *C of G*. With a little practice the needle can be inserted into the holder, adjusted to great sensibility on the support, and finally magnetized in less than two minutes.

* School Science and Mathematics.

BUILDING A TRANSATLANTIC LINER.

THE "KRONPRINZESSIN CECILIE."

BY THE BERLIN CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

WHILE the arrangements provided for the comfort of travelers on international express trains are necessarily limited by space considerations, no such restrictions are met with in improving transoceanic steamers. In fact, those built during the last decade are fitted up with the most lavish luxury, and in their interior appointments excel the majority of first-class hotels. As the safety afforded by these steamers at least equals that of railway trains, the ocean passage is now considered a pleasure trip rather than a fatiguing journey.

The progress that has been made in steamship construction during the last twenty years is best indicated by the fact that the express steamer "Lahn," which was built for the North German Lloyd in 1887, and which at that time was considered a marvel of perfection, was recently sold as scrap iron at the same time that a new fast steamer, the "Kronprinzessin Cecilie," was launched. As the latter, though a sister ship to the "Kaiser Wilhelm II.," contains a number of improvements that go to make her one of the fastest and most commodious ships afloat, it will be interesting to briefly describe how such an ocean giant gradually comes into being.

The first task is to erect the iron scaffolding or cradle and to lay the keel blocks, after which the keel itself and the double bottom are constructed. The latter, which contains twenty-six cells, is an important factor in the stability of the vessel. Not only does it provide a most efficient protection against any damage that might happen to the bottom; but it also serves as a receptacle for the fresh-water supply required for drinking and for feeding the boilers. It affords a means, by filling the cells with water, of outbalancing the influence which the consumption of coal and provisions is bound to have on the stability of the ship. In order to give an idea of the dimensions and capacity of the double bottom of the "Kronprinzessin Cecilie," it should be said that the horizontal central portion consists of four shell plates of a total thickness of 2.76 inches which are firmly riveted together. In the place where it forms the bed for the engine it is nearly 6.89 feet high. The cells hold 264.22 cubic yards of fresh water for the boilers, 1,132.73 cubic yards of water for drinking purposes, and 2,742.88 cubic yards of ballast water, giving an aggregate of 4,139.83 cubic yards of water, which is somewhat larger than the displacement of an up-to-date second-class cruiser.

The growth of the steel monster at first takes place at a slow rate. The double bottom forms the ground floor as it were of the floating building, and above it rise seven stories varying in height from 7.51 feet to 14.08 feet. The total height from the top line of the keelson to the top of the smoking room, the roof of which pierces the awning deck, is 72.72 feet, which is the height of an average four-story house.

The upper deck is laid at an advanced stage in the construction of the liner. Below this deck there are the main, lower, and orlop decks, and above it rise the following superstructures:

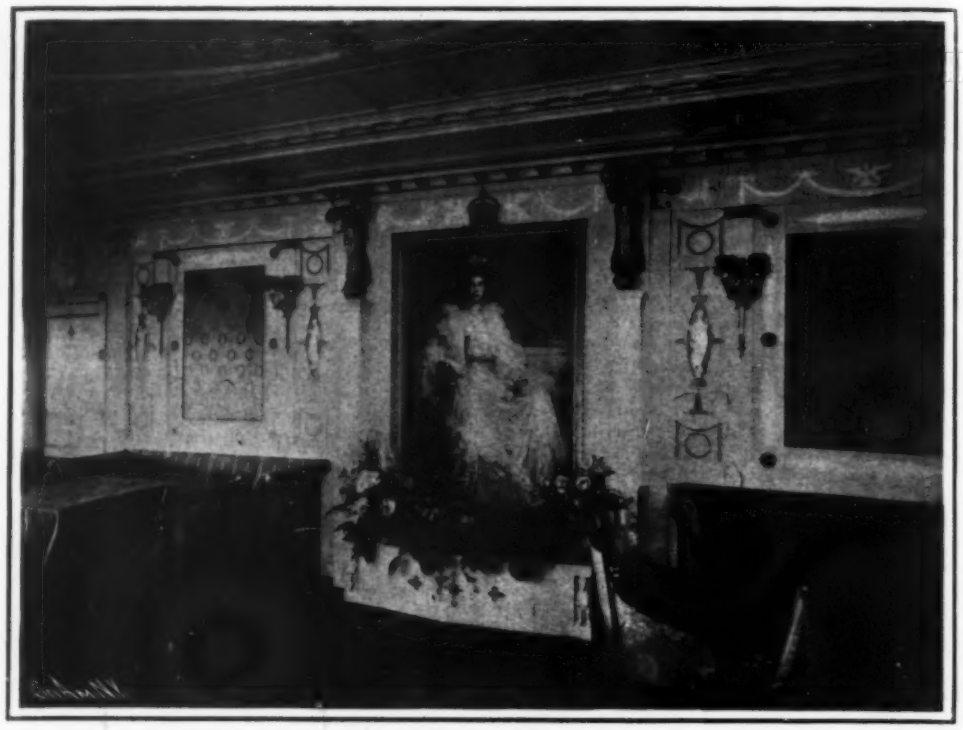
First, a spar deck extending the whole length of the ship, the middle and after parts of which serve as a lower promenade deck. On this deck there is amidships a deck house, 442.93 feet long and 53.48 feet wide, while farther aft there is another deck house, 78.72 feet long.

Secondly, a forecastle, and above the midship and aft deck houses an upper promenade deck, 537.92 feet long, on which there are two more deck houses, measuring 437.88 feet in length and 26.24 feet in width.

Thirdly, a boat deck, 451 feet in length, and another one aft, 255.84 feet in length, above the last two mentioned deck houses.

A number of comfortable and sheltered promenades are thus provided on two decks alongside the deck houses, allowing passengers to enjoy the fresh air. A special sheltering device, invented by one of the directors of the company, will enable them to remain on deck enjoying the invigorating sea air even in a strong wind. Part of the boat deck is likewise available as a promenade deck or for deck games. In fact, the whole deck space reserved for promenade purposes covers an area of 33,906.6 square feet.

When the construction of the lower part of the hull is completed, the less laborious steel plating of the hull makes comparatively rapid progress. The frames or ribs are fitted with a thick coating of steel plates, which envelop the enormous skeleton, giving it a graceful appearance. Of great importance in this phase of the construction is the installation of the bulkheads, which are so instrumental in increasing the safety of the ship. After this, the engine plant is installed gradually.



FIRST-CLASS DRAWING ROOM.

From the moment of the laying of the keel to the launch of the vessel, a total weight of about 11,000 tons was built into her. In order to transport this amount of material, 1,100 railway cars of the ordinary German freight train type, or twenty large freight trains, would be required.

Outside of these 11,000 tons of steel plate and other building materials, about 700 tons of rivets and screws, 300 tons of various cast and wrought-iron materials, 1,572 cubic yards of teak wood, about 2,620 cubic yards of Oregon and pitch pine, and 720.5 cubic yards of pine wood were used in construction of the vessel.

The steamer measures 706.31 feet from stem to stern, a length exceeding the height of the Statue of Liberty by 400.16 feet. The maximum width of the vessel is close upon 65 feet, the height up to the side of the upper deck about 42 feet, or 134 feet up to the top of the smokestacks. The draught of the steamer when fully loaded is 30.01 feet, and her displacement 27,000 tons. The tonnage is 20,000 gross registered tons. The weight of the hull at the time of launching amounted to as much as 11,220 tons.

In designing the interior appointments of the vessel (which accommodates 742 first-class, 327 second-class, and 740 third-class passengers) many architects have been granted the opportunity to give expression to the most varied tendencies of modern art. Only the main dimensions of each room were set by the company, while constructors were given perfect liberty in developing the interior arrangements. Novel features of the vessel are the restaurant service, which has been substituted for the table d'hôte dining at fixed hours, and two Vienna cafés, for smokers and non-smokers respectively, on the awning deck.

While the dimensions of the new steamer are the same as those of the sister ship "Kaiser Wilhelm II.," her engines have been reinforced considerably in comparison with those of the latter and with other fast steamers of the same class. In fact, their aggregate horse-power is 46,000, as against 45,000 in the case of the "Kaiser Wilhelm II." and 28,000 in that of the "Kaiser Wilhelm der Grosse." Though the average performance according to contract is only 23.5 knots, slightly more than that of the sister ship, the builders of the "Kronprinzessin Cecilie" still hope to develop a speed as high as 25 knots.

SMOKING CAFÉ.

THE BUILDING OF A TRANSATLANTIC STEAMER.

In addition to the double bottom, which extends throughout the length of the ship, a number of other safety arrangements have been installed, of which the 17 watertight bulkheads are the most important. These have been given such ample dimensions that the vessel, even in the case of leaks in two neighboring compartments, would remain afloat. Twenty-four out of the fifty-three bulkhead doors have been provided with automatic locking devices on the Lloyd-Stone system, and are locked from the pilot house at a moment's notice. A map in the chart house enables the captain to ascertain at any time which water-tight doors have been locked.

In case part of the vessel should become waterlogged, there are 17 steam pumps ready to raise 5,000 tons of water per hour. The boilers and engines consist of four different sets, each of which is placed in a separate water-tight compartment, so that even if one steam boiler or engine is damaged, there is enough steam power left to propel the steamer. Additional safety is afforded by 28 life-boats, 21 fire-alarm bells, another complete plant of alarm bells, and 17 signaling apparatus distributed throughout the decks of the vessel. A pipe system with hose connections communicating with special pumps extends throughout the vessel, and as it can be made to connect with steam pipes leading to the various rooms, affords an effectual protection in the case of fire. In the smoking rooms of the first and second cabins, and in the Vienna café for smokers, electric cigar lamps are provided; while in the first and second-class staterooms electric current may be switched on for curling tongs and ventilators. The necessity for striking matches is thus greatly reduced.

From the captain's bridge a complete telephone system for two loud-speaking telephones runs to the engine room and to the telephone box on the after boat deck. Besides this, there is an ordinary telephone connection from the bridge to the crow's nest, from the captain's room to the officers' quarters and to the first pantry, from the chief steward's office to the purser's office and to all the "Imperial" apartments, "cabines de luxe," and special staterooms.

For communication with passing vessels and the shore there is provided a complete wireless telegraph, long-distance outfit. This enables the ship to keep up a constant communication with the land, so that the latest news can be published on board in a daily newspaper, for which a special printing office has been fitted up. The wireless telegraph station is installed in a house on the roof of the non-smokers' café. Besides the telegraph operator's office, this house contains a public office for the use of passengers, and a bedroom for the operators.

Another means for communicating with passing vessels is afforded by a submarine bell signaling apparatus, which has done good service in foggy weather.

Of the other technical installations on board the "Kronprinzessin Cecilie" should be mentioned well-isolated refrigerating chambers for provisions, an ice storeroom, and large provision storerooms. The bunkers, which are situated forward of, aft of, and on the sides of the boiler rooms, hold about 5,600 tons of coal. For the handling of cargo, baggage, and provisions, six steam winches are provided on deck. Part of the lifeboats are made of wood, while the rest, as well as the semi-collapsible boats, are of zinc-coated steel plates. Four steam boat hoists are provided on the boat deck to insure a quick launching of the boats.

This ocean giant requires a crew of 650 persons, comprising, besides the captain, 24 officers, including doctors, pursers, and post office clerks; 61 machinists, electricians, boiler smiths, and oilers; 231 head stokers, stokers, and coal trimmers; 229 stewards, stewardesses, and 'tween deck stewards; 33 cooks, bakers, butchers, and confectioners; 9 barbers, hairdressers, booksellers, baggage-masters, and wireless telegraph operators; 33 scullery men and pantry men; 59 coxswains, and various deckhands and sailors.

In order to serve as a cruiser in time of war the ship has been provided with emplacements for a large number of guns, and the rudder, steering gear, and reserve steering gear have been located below the waterline.

VARIOUS METHODS OF RECOVERING RUBBER FROM WASTE.

GOODYEAR reduced vulcanized rubber in a hollander or ragmill, mixed it with pure rubber similarly reduced, and repeatedly passed the mixture through hot rollers until perfect combination was secured A quantity of sulphur, proportionate to the amount of the new rubber, was added.

Bacon pours 100 parts of sulphide of carbon and 2.5 parts of alcohol over 1,000 parts by weight of vulcanized waste, allowing it to stand in a closed vessel for two hours; after which the mass is sufficiently softened to be worked up.

Parkes allows 8 to 10 parts of finely divided waste to boil in a concentrated solution of 20 parts of calcium chloride, until it is softened, so that two pieces can readily be kneaded together. The pieces taken from the fluid are first washed in a hot alkaline solution, then in hot water, and can then, according to the statement of the patentee, be worked over again.

Dodge recommended the division of the scrap as finely as possible, after which it was placed in a jacketed cylinder, arranged for the admission of steam between the inner and outer walls. A temperature of 150 deg. C. (300 deg. F.) is maintained until the waste is plastic and it is then mixed with fresh rubber; or to 5,000 parts of waste 100 parts of palm oil, 170 parts of sulphur and 1,500 parts of white lead, zinc-white, magnesia or alumina (clay) are added and thoroughly incorporated with it.

THE SKELETON.

A new, improved process of recovering waste and the zinc contained in this material, was invented by Burghardt of Manchester and patented by him in England. According to this process, the scrap is thrown into a vessel made of wood or lead and covered with hydrochloric acid of such strength as will serve to completely destroy the attacked fabric, the waste being then boiled in it until the rubber is completely freed from all fibers. The solution contains zinc and chloride of calcium, sometimes also chloride of lead, and is treated as will be later described. The rubber is now transferred to a vessel containing water and boiled until all acids and zinc or other chlorides have been removed.

The solution which is thus obtained is added to the one already described. The purified rubber is placed in a jacketed vessel made of wood, copper, iron, or lead, a sufficiency of alcohol, wood, petroleum, benzole, or any other solvent added, the vessel closed tightly and the whole raised by means of steam, gas or hot air to a temperature of about 240 deg. F. until the rubber is dissolved or transformed into a thick, doughy mass. When this has been effected, the naphtha, according to the Chemiker Zeitung, is distilled off at a temperature not exceeding 212 deg. F. The above-described solution is then placed in a vessel and treated with a sufficient quantity of bicarbonate of soda, carbonate of potassium, or caustic soda, to precipitate the zinc, calcium or lead. The precipitate is rubbed down in running water, by which means the calcium carbonate, being lighter than the zinc carbonate, is carried away. The zinc carbonate is dried.

Ludwig Heyer, manufacturer of rubber goods in Berlin, employs the following process for the recovery of old vulcanized rubber: Old, rejected buffer rings, from railroad cars, are heated in the presence of water vapor. The sulphur distills off, the rubber melts and runs into the hot water, where it collects at the bottom of the vessel. The water vapor prevents the burning, or burning fast, of the material. The melted rubber has acquired properties differing materially from those it originally possessed. It has become a fairly thin fluid, dark mass that remains fluid at ordinary temperature, soon dries if exposed to the air and has retained its waterproof property. On the other hand, it has lost its elasticity, at least for thick pieces. Heyer uses this fluid rubber mainly in making waterproof covers for carriages, railroad cars, ships, etc. This rubber is also to be recommended as a waterproof varnish coating for hardware goods.

Dankwerth and Köhler in Petersburg have patented a process for the treatment of old rubber, to produce from it oils, varnish, and materials for mixing with rubber and other substances. Old rubber is subjected to dry distillation in a retort, by fire or superheated steam. During this process volatile constituents of the rubber are carried over and when condensed, form oils and a substance which, when vulcanized, possesses, in a high degree, the properties of natural rubber. The light oils, passing over at 140 deg. to 250 deg. F. are separated from the heavier; the first serve directly for the production of varnish, the others are mixed with hempseed, linseed, and other vegetable

BEDROOM OF THE IMPERIAL SUITE.

THE BUILDING OF A TRANSATLANTIC STEAMER.

oils and then, in the ordinary manner, by boiling or chemical action, are transformed into varnish. The mass to be still subjected to vulcanization, is thoroughly mixed by means of rollers and from 7 to 20 per cent of sulphur added to it.

Artificial rubber can be made as follows: In an iron kettle place about 10 parts, by weight, of sulphur, or flowers of sulphur, and 20 parts of rapeseed oil and heat the mass, constantly stirring the while, until the sulphur is melted and a condition is reached in which the mass puffs up. At this stage it must be quickly poured out, either into molds well dusted with some powder or onto stone plates, wet with water, upon which it sets and displays properties very similar to rubber; it is soluble in linseed oil. The mass can also be prepared with linseed oil, but in this case less sulphur must be used. The kettle should not be more than half full, otherwise the mass may run over.—Translated from the German of Theodor Koller in "Verwertung von Abfallstoffen Aller Art."

VERDE-ANTIQUE FINISH.

ITS RAPID PRODUCTION AND METHOD OF OBTAINING THE VARIOUS SHADES.

THE verde-antique finish, in its various shades, is now one of the most popular. At the same time, it is imperfectly understood. Workmen who are doing it successfully endeavor to preserve it as a trade secret, and although much has been published on the subject, some of the directions for the production of certain and rapid results are lacking. To turn out a creditable piece of verde-antique work is not as difficult an operation as it may seem, and when a few simple points are borne in mind, even inexperienced persons can produce good work.

It was formerly believed that the solution used for corroding is the secret of the operation, but this is of little importance compared with other features. All that is needed is something to act upon the metal and form a basic carbonate of copper. To be sure, certain kinds of solutions work more rapidly and give better results than others, but to believe that a "verde" cannot be produced except by a solution which contains accurately weighed and complicated ingredients is untrue.

The pigment process for the production of the finish is rapidly falling into disuse. The results are not satisfactory and it is difficult to produce a pigment coating that will not peel or strip. The appearance, too, usually is not artistic and the article looks as if it had been painted. Even to the untrained eye such articles reveal the method by which they are made.

When verde finishes first made their appearance, pigment was more used than at present, as it was the only method generally known; and as it is easily applied, it was natural that it should have been so extensively used. It was soon discovered that it lacked artistic value and was far inferior to the genuine verde produced by the corrosion process. A comparison of the results obtained by both processes will soon demonstrate this.

For those who are not familiar at all with the production of the verde-antique, let it be said that the pigment process consists in applying a lacquer or paint containing a green pigment, such as carbonate of copper or chrome green, to the surface of the article that is to be treated. The process practically amounts to painting the surface with a green paint, but with the exception that the paint dries dead instead of glossy. Those who know the difficulty with which paint adheres to a metal surface, will readily appreciate that blistering or peeling is apt to occur on verde-antique surfaces produced by the pigment process.

The name verde-antique is one of the terms that has been borrowed from the French language. The word, verde, is the old and now obsolete spelling of the French name for green. It is written either as verde or verd, and as the finish is made to represent old wares, it is fitting that an obsolete term should be applied. The modern French name for green is vert, but this is rarely found in literature to designate the green finish found on metal wares.

The name "antique" is the French term for ancient or old. The compound word verde-antique, therefore, means old or ancient green.

The green compound that is formed on the surface of copper, bronze, or brass articles when they are corroded, either naturally by the action of the atmosphere, or by artificial means, is a basic carbonate of copper. The more perfectly this compound is formed, the more beautiful the results. Such a basic carbonate of copper is found in Nature as a mineral called "malachite" with which nearly everyone is familiar. When well formed, specimens of malachite are not only one of Nature's most beautiful products, but quite expensive.

The formation of other compounds on the surface of the metal that is corroded results in less beauty. The basic chlorides and also the basic nitrates, which are produced when certain solutions are used, are not as satisfactory as the basic carbonate. A blue shade is also undesirable. The color which seems to be the most pleasing is the dark green.

While there are several essential features in the production of the verde-antique by the corrosion process that need careful attention and are generally unknown, there is one which is, without doubt, paramount to all the others. When it is known, verde-antique becomes a comparatively simple matter. *This "secret" is to keep the surface of the metal to be corroded constantly moist and warm by means of a damp, heated atmosphere.* Ignorance of this one feature has been the reason why many persons have not succeeded with the process. They have applied the solution to a properly prepared surface, but have allowed it to dry within a short time. When dry, the solution becomes inert and does not act upon the metal. When maintained in a moist condition, it constantly acts upon the metal. As heat accelerates chemical action, a warm atmosphere greatly hastens the action. When

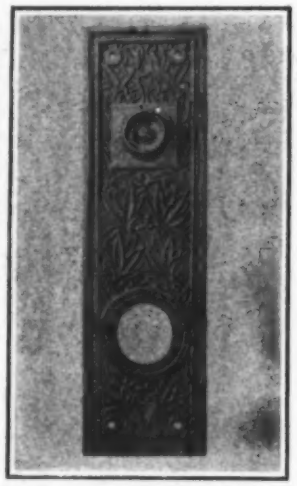


FIG. 1.—VERDE PRODUCED ON BRONZE IN TWO HOURS.

the temperature is excessive, however, the action is not as good, and care must be taken that it is not raised too high.

If those who desire to produce a good verde in an expeditious manner will try the following experiment, they will surely believe in the wisdom of the preceding remarks:

Take a bronze or composition casting and dip it so that the surface is perfectly bright and clean. Now allow it to dry. Next brush over the surface one coat of the solution subsequently given in this article for the production of the verde-antique.

Then immediately place the casting under a glass bell-jar before the solution has begun to dry. Place a layer of sawdust in the bottom of the bell-jar and saturate it with the verde-antique solution. In the middle, place a block of wood or any object to raise the casting from the sawdust. The casting should thus be raised near the top of the jar. Place the jar in the sunlight on a hot summer's day, or in a warm place in the winter. Now watch the corrosion take place. In fifteen or twenty minutes the surface will become covered with a green film, slight, but perceptible. This

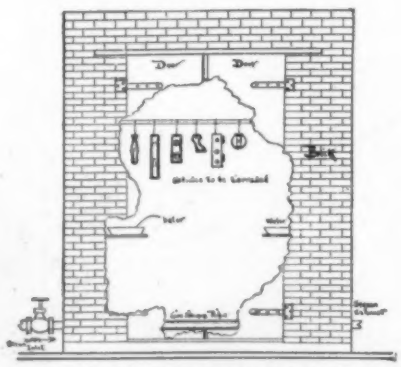


FIG. 2.—KILN USED FOR PRODUCING VERDE-ANTIQUE.

gradually becomes more apparent and intense. At the end of an hour fairly good green has been produced. At the end of two hours, a verde sufficiently good for many purposes will have been formed. If the casting is now removed and allowed to dry in the air, the green coating will become more intense and the effect of the corrosion will be manifest. If another casting of the same kind be corroded by treating it with the same solution and allowing it to dry in the air, the good effect of the moist, warm atmosphere will at once be seen.

For the production of verde finishes by the corrosion process, there is no metal that can equal pure copper. Bronze composition or any similar red metal works nearly as well, but yellow brass, on account of the large percentage of zinc that it contains, does not give as good results. If the following directions are followed out, however, it will be surprising how good a verde may be obtained on yellow brass. The color is not quite as good, nor is the corrosion as rapid. For many purposes, though, it will answer.

Spelter, antimonial lead, iron, or similar metals must be copper plated with a very heavy deposit of copper before the corrosion can take place. To produce such a heavy deposit, the object is first given a twenty-minute deposit in the cyanide copper solution to cover it. This is preferably used hot, as its covering power is then greater. The object is next transferred to an acid copper solution, and a deposit of from two to three hours at least is given it. The corrosion is so deep when the verde is produced, that unless a very heavy acid copper deposit is put on, it will be removed in corroding. An acid copper deposit, too, is an excellent one for corroding, as it is porous and easily attacked.

For the rapid production of verde finishes by the corrosion process, a sand-blasted surface is the best, as it is clean and rough. The corrosion takes place much more rapidly on such a surface than it does upon one that has been dipped. Those who are not supplied with a sand blast, however, will find that equally as good results may be obtained upon a dipped surface, but the corrosion usually takes a little longer. There are many designs upon metal work, too, that cannot be advantageously treated with a sand blast. Plated surfaces also cannot thus be treated.

A most satisfactory surface for corrosion is the copper deposit from the acid copper solution. It is clean and somewhat porous. Its crystalline nature, and also the fact that it is pure copper act favorably.

Smooth surfaces do not allow the solution to act readily and should be avoided wherever possible. To be sure, they may be corroded, but the solution does not adhere as readily as it does to a rough surface and the action is slower. Metal should be dipped wherever possible, as this not only serves to clean it, but to roughen the surface as well. An acid dip which contains considerable aqua-fortis is the best for the purpose. The rough surface that is thus produced corrodes readily. Such a dip is made by taking the following:

Aqua-fortis ..... 1 gallon.
Oil of vitriol..... 1 gallon.

The metal to be corroded must be as clean as though it is to be plated. Grease not only prevents the solution from adhering, but also retards its action on the metal. After cleaning in the usual manner, the metal is run through the dip and cleaned so that the surface is bright and uniform. It is now ready for corroding.

Light and dark verde finishes may be obtained in the same solution by a preliminary oxidizing. If the corrosion is allowed to take place upon the surface of the copper, bronze or brass without previously oxidizing, a light verde will be produced. In this manner it is possible to obtain any shade that may be desired.

In case a light-colored verde is desired, the solution may be applied directly to the surface of the cleaned metal without any preliminary oxidizing; but if a dark-colored verde is desired, it is imperative that the metal should be oxidized.

Copper, bronze, composition, or similar red metals are oxidized in the regular liver of sulphur solution. The sulphur is made by dissolving 2 ounces of liver of sulphur in 1 gallon of water. It is used *cold*. If used hot, the black sulphide of copper will wash or brush off. It is not adherent when produced in a hot solution. Yellow brass is oxidized by dissolving ½ pound of plastic carbonate of copper in 1 gallon of ammonia. This is used hot and the brass immersed in it. It will become colored black.

If it is desired that the raised portions of the article shall be light colored and the deep portions of a dark shade, the parts in relief may be scoured off with pumice and water so that the bare metal is exposed. In this manner two different shades on the same surface may be produced. The most satisfactory surface, however, is that in which the background is green and the raised parts of a green black without any carbonate of copper on them. A dark, olive green is the most pleasing for the portions in relief.

There is a large number of solutions which may be

used for corroding the metal. Some are good, others unsatisfactory. One of the best for this purpose is the following:

Water	1 gallon.
Sulphate of copper	8 ounces.
Sal-ammoniac	8 ounces.
Common salt	4 ounces.
28 deg. acetic acid	2 ounces.
Chloride of zinc	1 ounce.
Glycerine	1 ounce.

The glycerine is used to prevent the solution from drying on the surface too rapidly, but if the amount given is increased to any great extent, the final drying of the surface is difficult. The chloride of zinc is also a non-drying compound and acts in a manner similar to the glycerine, but it is corrosive as well.

The whole of the ingredients may be dissolved in the water at once. It is used hot on the surface of metal that has not been oxidized. On that which has thus been treated it is brushed while warm. The clean metallic surface of an object immersed in the hot solution will quickly be changed to a dark green patina. When the metal has been dipped and removed from this hot solution, it will dry spontaneously. It is then allowed to cool and some of the solution brushed over the surface.

Whether the object has been dipped or brushed with the solution, the excess is allowed to drain off. If it is allowed to remain in pools in the crevices and deep portions, it will not act uniformly. The object is to have a uniform film of the solution over the entire surface. When this has been done and the surface is still moist, the object is immediately transferred to the "kiln" before the solution has the opportunity to dry.

The kiln used is a very essential part of the process. Without it, the results can neither be rapidly nor as satisfactorily obtained. Its value is not generally appreciated, nor is its use widely known.

This kiln is simply a tight chamber containing a moist and warm atmosphere. For small work, a glass bell jar is excellent. For larger work a wood box may be used, but in establishments where there is much work to do, one made of brick is the best. Such a kiln is shown in Fig. 2. Corrosion of the metal surface takes place far more rapidly and deeply in a warm, moist atmosphere than it does in one that is dry. Such is the principle of the kiln.

The kiln shown in Fig. 2 is made of brick and a steam pipe passes through the bottom. A simple straight pipe through it is all that is necessary, as a large coil gives too much heat. The brick is constantly kept moist by water if necessary and any other means, such as pans of water or wet sawdust, may be taken to keep the air in a moist condition. It is absolutely necessary, however, for the rapid production of the verde that the atmosphere be maintained in a moist and warm condition.

The temperature of the kiln should be carefully adjusted. A very small amount of steam only is required. If desired, the interior may be heated by other means, such as an oil or gas stove. A temperature of from 100 deg. to 120 deg. F. has been found suitable.

The doors are tightly closed and the corrosion allowed to go on. After an hour or so, the surface will have corroded considerably, and it will be found advantageous to remove the objects and dry them in the air or a lacquer oven. This is not absolutely necessary, but the results, if one has the time to do it, will pay for the extra time consumed. When dry, another coat of the solution is given the surface and the object is again put into the kiln.

For quick work, the article treated is allowed to remain in the kiln for from two to three hours when a fairly satisfactory verde will have been produced. From ten to twelve hours gives a much better one, however, and usually good enough for all purposes. By putting the articles in the kiln at night, they will be ready in the morning.

When the article has been taken from the kiln, the surface is still moist. The best method is to allow this to dry off in the air, but if desired, it may be dried in an oven. The surface is now brushed with a stiff brush to smooth down any excrescences that may have formed, and it is ready for lacquering.

The object is now lacquered with one coat of a flat lacquer and allowed to dry. The surface is then waxed by means of a bristle brush and paraffine wax. In this manner an excellent appearance is imparted to it.

A variety of novel verde finishes may be produced by modifying the treatment. By stippling on the solution by means of a brush, before the corrosion has been carried out, a mottled verde may be produced. When it is desired that the background of the surface shall be dark green in true verde and the raised portions in dark, olive-green patina, the metal is oxidized in the manner previously mentioned and the solution applied. The object is transferred to the kiln as usual. After about an hour, when the surface has been colored to a dark green patina, the object is taken out and the raised parts wiped off with a cloth. It is then returned to the kiln and the corrosion allowed to go on. In this manner the surface is prevented from further corrosion, while the deep parts will continue to corrode in the desired manner.

Some operators use carbonic acid gas in the kiln for producing the verde-antique. Whether this actually aids the operation or produces a better verde is an open question. Although malachite is a basic carbonate of copper, free carbonic acid does not act upon copper. It must be combined with other substances in order to do it. On the other hand, the carbonic acid gas does no harm in the kiln, and those who wish can use it. From the meager experiments that I have made upon its use, I believe that it is of little value and I do not employ it.—The Brass World.

INCREASING THE BOILER CAPACITY.*

HOW A PLANT SHOULD BE INSPECTED.

BY GEORGE P. PEARCE.

As a mechanical engineer, I have been brought into contact with a great variety of power installations, and I should estimate that eight out of every ten of the smaller, say up to 300 horse-power, and many of the larger, are operated in a very unsatisfactory and unprofitable manner. The boilers have the capacity, but they are run under such miserable conditions that only about 40 to 60 per cent of their rated power can be obtained, when a little "know how" and a comparatively small expense would easily and safely allow these boilers to be run up to 120 per cent or more, of their rated capacity.

The other day I was called to a small boiler house and asked if there was any way to avoid the purchase of a second boiler, as the one they had did not give enough steam. The boiler was in good shape and was fired nicely, but I noticed the fire did not burn as briskly as it ought to, although the damper was wide open. I stepped outside and looked at the stack; there was the trouble, a miserable 25-foot sheet iron affair with a great dint in one side on account of having blown down several years ago. It was also of smaller diameter than it should be even for a 60-foot stack. "Cut out the dint and add 40 feet to the stack, and you will get all the steam you can handle"—and they did.

"Come to the mill at your earliest and see what is the matter with the power," read a letter one morning. When I arrived there I found that they had just put in some new machinery, and although everything would start up all right in the morning, yet about 10 A. M. the engine would begin to slow down to about two-thirds speed; the same thing also happened in the afternoon, and no matter how the engineer tried he could not get the steam up. "Boilers, again," I said, and we went into the boiler room. There was a nice, brisk fire and a good 60-foot stack. This was about 8 A. M. I decided to stay around and wait for the power to drop. I noticed the coal was a poor grade of bituminous, containing a large quantity of dross. Pretty soon one side of the fire began to lose briskness and appear as though the draft was poor. I picked up the scraper and cleared part of a grate bar; there was the "hoodoo," a fine herring-bone grate, designed for burning rice coal, the bars of which were becoming covered with a glass-like layer of dross which the engineer could not cut off with the slice bar without leaving the doors open long enough to lose steam. He had thus been getting along the best he could until noon hour, when he would clean his fires and "bar" most of the dross off. Of course the same thing happened in the afternoons. A first-class shaking grate completely cured all trouble here.

Jones had trouble with his boilers. He had two boilers and five engines, and he could not get a sufficient amount of steam. He had a good, well designed boiler-house, evidently equipped by a man who knew the business, so there was nothing wrong there. He was evidently getting plenty of steam and certainly was burning lots of coal. I looked at his engines—small slide-valve affairs speeded up to the limit, pounding and rattling around as though every bearing had ⅛ inch wear that needed taking up. I thought I would indicate one, but found it had never been tapped for indicator connections, so I climbed out on the roof to have a look at the exhausts. There was only one exhaust head connected by a tee to two exhaust lines; three engines were on one line and two on the other. The exhaust steam from one line was charging head-on into the exhaust from the other; the exhaust pipes were much too small, and so was the exhaust head. I found out afterward that only two engines were originally used, and three more had been added on to the old lines. I borrowed the steam gage from the boiler and attached it to one of the exhaust pipes; it showed between 12 and 15 pounds. I also noticed that great quantities of hot water were used for soaking and washing purposes. This was heated with live steam. Upon investigation, it proved that a very small quantity of oil in this water would not be harmful, so I started in to make a few changes. First, two new larger exhaust lines were put in, the one from the two engines going to the old exhaust head, and the one from the three engines discharging into a new head. An automatic back pressure valve was placed on each line and set to three pounds. The engines were all equipped with automatic positive feed lubricators, which I set to feed about 1½ pint per week, or about 1-10 of what was going through the old sight feeds. Then the exhaust steam was connected to the large water heating tanks. These changes alone made a great saving in steam, it now only being necessary to lightly fire the boilers. At the first opportunity I had the engines thoroughly lined up and rebabbitted, and at the same time had them drilled for indicator connections; then I carefully set the valves. This, combined with the lining up and overhauling, reduced the steam consumption so much that one boiler could easily be forced to do all the work. These are only a few instances where considerable expense was saved by proper attention to what may have appeared to be small details.

Let me advise all who are considering the installing of more boilers to carefully go over every detail of their present plant. See that the air spaces in the grate bars are correct; see that the fireman keeps his fires clean, fires evenly, and at regular intervals. Examine the bridge wall and see that it is not built too high or covered with a thick layer of soot; see that the side walls do not allow air to leak in; see that the combustion chamber is clear and the flues regularly kept clean. Next get inside the boilers and see how much scale is round the flues and plates. Be sure that the steam line gets only dry steam. Test the draft, and if poor, measure the stack for length and area and make it right. Look up the feed-water lines, and if you are using an exhaust feed-water heater, see if it is delivering water to the boiler at least 200 deg. F. If not, find out what is the trouble; perhaps the pipes are so choked up with scale that the water has to go through with considerable velocity, thus not being in the heater long enough to absorb sufficient heat. The water is also insulated to a considerable extent by the scale. Then again the drip pipe may not be taking the condensation away fast enough, and the heater be partly filled with cool water. If you have not got a feed-water heater, get one, or make one; a barrel and some old pipe will do. If you now have got the boilers in good shape, and they are generating as much steam as boilers of that size can be expected to do, follow up what is being done with the steam. When did you have the engines indicated last? Are they running up to their full economy? Where is the exhaust steam going? Are you using live steam anywhere, where exhaust would do? Do not say you cannot use the exhaust, because it contains oil; a good oil separator will remove that. Remember exhaust steam is condensed and used for artificial ice—you don't taste oil there. Go over the steam traps and look for leaks. I know of cases where large steam traps have been blowing steam into a sewer for months before the loss was discovered. Also look over the steam lines and see that they are thoroughly protected against condensation. Then, after going over every detail in this manner, if you still find the steam supply insufficient, it is time to start considering an extra boiler. I would warn superintendents against placing too much reliance upon the boiler tests run by the engineer, as he naturally wants to show good results, and so gets conditions that are not every-day conditions while running the test.

* Abstracted from Machinery.

Since 1890, 540 buildings of ten or more stories have been erected on Manhattan Island. Twelve stories is the favorite number above ten, apparently, for 169 twelve-story structures have been built or are now under way. Less than a dozen years ago the American Surety Building, at 100 Broadway, twenty stories high, was a world wonder. Now it is insignificant compared with some others. The Singer rises forty-one stories and the Metropolitan Life, now under construction, will break the record with forty-eight.

THE AUDION.—I.*

A NEW RECEIVER FOR WIRELESS TELEGRAPHY.

BY LEE DE FOREST.

THE story of the development of a device of a distinctively new order, from its first inception to its practical reality, adds a human interest to its description which is perhaps too often lacking among scientific records. In 1900 when I was beginning experiments on the electrolytic responder, it was my good fortune to have to work upon it at night in my own room, at a table beneath a solitary gas burner with Welsbach mantle. My source of Hertzian waves was the discharge of a small induction coil placed in an opposite corner and set into operation by a key closed by pulling a string.

One night I noticed to my surprise a decided diminution in the light from the incandescent mantle whenever the coil was sparking. The constant recurrence of this effect induced me to investigate. By proper adjustment of the inflow of gas and air to the burner, an almost complete extinction of its light was obtained during the sparking of the coil. Another adjustment even allowed an increase of the light above normal. For several days I was elated over the tremendously sensitive and altogether novel type of Hertzian-wave responder thus accidentally discovered. But alas for the over-sanguine spirits of the young investigator! When I thrust my induction coil into a closet and closed the wooden door, thus shutting off the sound of its vibrator and spark, my gas light ceased to fluctuate.

I found I had merely discovered an extremely responsive form of the sensitive gas flame, and that a bunch of jingling keys or a smart clapping of the hands were almost as efficient generators of these Hertzian waves as was my induction coil. To hopes unrealized this was indeed the "light that failed."

But the few days of illusion had set me thinking. Here in the flame around this incandescent mantle was matter in a most mobile, tenuous state, extremely sensitive to sound and heat vibrations, infinitely more delicate than any arrangement of solid or liquid particles. Why should it not then in some phase or fashion respond to the Hertzian vibrations also?

Unable to dislodge this conviction from my mind, I began later to search for the genuine response to electric vibrations in the gas flame. I found the conductivity of the incandescent mantle surprisingly small, however, for any voltages which would be practical in a wireless receiver.

By soaking the mantle in a potassium or sodium solution and drying, I was finally able to pass a small current from a dozen dry cells through the flame surrounding it, using two platinum electrodes with a telephone receiver in circuit, and get a faint response to the genuine Hertzian wave. The discovery that the effect predicted was actually present was intensely gratifying.

Experiments followed with the Bunsen burner and other forms of flame. In the coal-gas flame the exterior luminous portion is positively electrified, the interior negatively. To render these flames sufficiently conducting, salts of the alkali metals were introduced. Of these the caesium, potassium, and sodium salts are

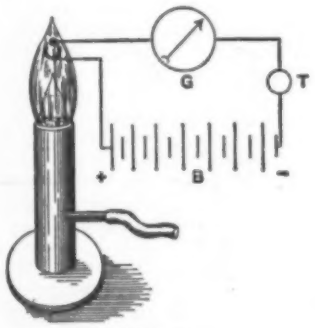


FIG. 2.

the most conducting, and in the order named. These salts were either injected into the flames, as solution, or preferably put in a little platinum cup held in the luminous part of the flame and made the cathode of the telephone circuit.

A platinum wire or disk held about 2 millimeters above this cup acted as anode. The antenna and earth connection, or the two terminals of the oscillating receiving circuit, were connected to these platinum electrodes. An electromotive force of 6 to 18 volts, supplied by a battery of dry cells, was sufficient to give a current of several milliamperes through the colored flame.

This early form of audion, the flame receiver, was remarkably sensitive to weak high-frequency oscillations. The sound heard in the telephone was an exact reproduction of that of the transmitter spark, in pitch, variation of intensity, etc.

It was observed that the increase of current with

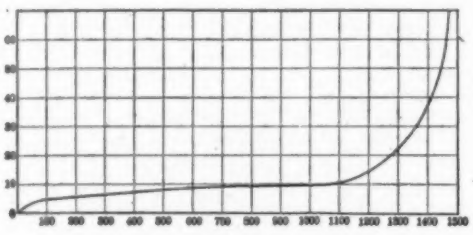


FIG. 1.

electromotive force did not follow Ohm's law; a saturation value of the current was observed. Wilson has found that the maximum current which a salt vapor in a flame can carry is equal to the current which if passed through an aqueous solution of that salt would electrolyze the same quantity of the salt as was imparted during the same unit of time to the heated gas.

Beyond this saturation value the current will not rise until the electromotive force is great enough to enable the field itself to ionize the gas; that is, until the velocity imparted to the negative ions by the field is sufficient to enable them to separate the gas molecules with which they collide into positive and negative ions.

The conduction through flames under the conditions I am describing is due chiefly to the negative ions generated, and these are chiefly in the vicinity of the metallic cathode. It is necessary that the alkali vapor comes in contact with the glowing metal. The increase of conductivity of a flame by the addition of a salt may amount to several hundred per cent, and is due not to the presence of the metallic atoms in the flame itself, but to the increase in ionization produced by the salt at the electrodes, notably the cathode.

The velocity of the negative ions in flame at atmospheric pressure increases rapidly with the temperature. Thus at 2,000 deg. C. their velocity is approximately forty times that at 1,000 deg. C. At 1,000 deg. C. the ratio of velocity of negative ions to positive ions is calculated as $\frac{26}{7}$. At 2,000 deg. C. this negative ion velocity in flames is about 1,000 $\frac{\text{cm.}}{\text{sec.}}$ for a potential gradient of one volt per centimeter.

Now suppose the average velocity of a negative corpuscle to be proportional to the electric force; this velocity, for a potential drop of 10 volts between the electrodes as I use them, is of the order required to traverse the distance between the incandescent body and the platinum anode during the time of one-half the wave period of the electrical oscillations ordinarily used in wireless telegraphy.

I shall return later to the bearing which this fact has upon a suggested explanation of the effect of the Hertzian oscillations upon the gas receiver.

On account of the ionization of the gas near the incandescent metal, and the greater velocity of the negative over the positive ion, it is to be expected that even if no external electromotive force be applied to the electrodes, and one of these be relatively cold, a current will pass along a wire connecting the two electrodes, whose direction is negatively from the hotter to the cooler body in the flame. In other words, the colder body will be the anode, positively charged.

Now, if the Hertzian oscillations traverse the hot gas, the momentary potentials thereby impressed upon the moving ions will conceivably interfere with their motions, or with the rates of recombination between the positive and negative ions, and thus effect the current flowing through the wire. A telephone connected between the electrodes indicates that changes of a surprising amount in the momentary potential difference, or flux, across the electrodes are effected by the high-frequency oscillations, even when no external battery is applied.

When a battery of from six to twenty dry cells is connected across the two electrodes, the positive terminal to the cooler electrode, the potential current curve for the conductivity of the gas it at first approximately a straight oblique line, the current through the flame increasing with the electromotive force.

Soon, however, this proportionality of current and voltage ceases, and a stage of saturation is reached where there is no appreciable increase of current with increase of voltage. But when the potential difference is raised sufficiently to ionize the gas, a stage is reached where the current increase is far more rapid than that of the potential difference. This last potential gradient depends upon the pressure of the gas; it is directly proportional to the pressure. This is given by Thomson as about 30,000 volts per centimeter for atmospheric pressure; but with incandescent gases in an inclosed vessel at one millimeter pressure a gradient of 40 volts per centimeter is sometimes sufficient to produce this critical stage.

In the case of the flame, the distances between the electrodes figure very little in the amount of current flowing, the potential drop, or the sensitiveness to Hertzian oscillations, because most of the ionization at low voltages takes place at the electrodes.

The size and shape of the electrodes are of small moment. I prefer a trough anode 1 centimeter long by 2 millimeters wide, holding the potassium salt, as cathode, and a small platinum wire parallel thereto and held 2 to 10 millimeters above it as anode.

The trough electrode should preferably be at the upper tip of the oxidizing flame at its junction with the reducing flame. When this is made negative the current is saturated with a comparatively small potential difference. The gas burner itself may be used as one electrode. The flame must be steady and kept rich in salt. The current of up-rushing flame makes a rumbling noise in the telephone, which may interfere with the detection of faint signals. This rumbling sound increases with too great applied potentials.

The temperature, especially of the electrodes, is an important factor. At red heat these give off positive corpuscles; at white heat both positive and negative appear, the latter predominating. The electrode containing the salt should always be incandescent, so that the excess of negative ions given off and streaming toward the other electrode will increase, rather than diminish the current due to the flame itself. The extreme sensitiveness of the flame when ionized to thermal variations is illustrated by the fact that a distinct response is heard in the telephone receiver when the mere tip of a cold pin is suddenly introduced into the flame. The sudden introduction of a cold body into the active part of the flame always reduces the response. The salt is best placed in, or on, one of the electrodes rather than held in the flame in an independent receptacle, or injected into the gas.

The applied electromotive force is a determining factor in the sensitiveness of this receiver. The response seems greatest where the potential current curve is passing from the oblique to the horizontal portion, where the saturation value is about to be reached. Under these conditions the sensitiveness of the flame audion is of the same order as that of the electrolytic

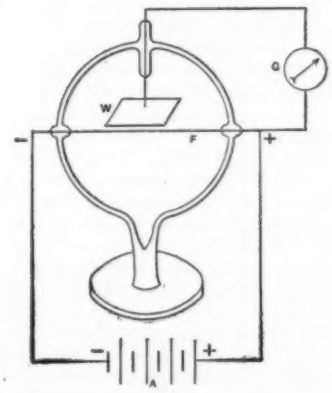


FIG. 3.

receiver using a glass-jacketed electrode. The flame is not most sensitive when the flux is greatest. There is a close relation between the degree of heat and the critical impressed voltage.

Considerable difficulty was found in getting an absolutely steady flame, even when protected by a chimney, as the slightest air current will deflect the sensitive portion from the electrodes, altering the sensitiveness of response.

I next sought the phenomenon in the hot conducting gases of the electric arc. If a wire be connected to the positive carbon of the arc and led through a telephone to a third electrode, platinum or carbon, which is inserted into the border of the arc, a considerable current passes through the telephone. If these two electrodes are now connected to the terminals of the

* For its name, Audion, a title as beautiful as it is appropriate, I am indebted to my assistant, Mr. C. D. Babcock, who has been of utmost service to me in the development of this device almost from its inception.

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receiving oscillating circuit, the conduction of the leak current across the gas to the third electrode is sensibly affected by the arriving Hertzian oscillations, if sufficiently intense. A local battery can also be inserted in series with the telephone, but the voltage drop across the arc is usually too great to require this.

Even when the arc is fed from a storage battery and cored carbons used, the hissing and frying noises in the telephone (probably due to the oxidation of the terminal by the air) are generally too troublesome to allow a clear reading of weak signals with this form of audion.

The principles involved in its operation are much the same as for the flame audion. And although the intense ionization produced by the heat of the arc renders it extremely sensitive to slight local variations, its practical requirements make it less available as a wireless receiver.

Inasmuch as the gases ionize more readily at lower heats and are in their most mobile, delicate, and sensitive conditions in vacuum, it seemed to me certain, after experiments with the flame, that the attenuated and ionized gases around an incandescent filament would undergo very considerable changes when subjected to Hertzian oscillations.

Elster and Geitel,* beginning in 1882 a systematic investigation of the ionization produced by incandescent metals, frequently employed an exhausted glass vessel containing an insulated platinum plate, stretched close to which passes a fine metallic filament brought to incandescence by an electric current.

Ordinarily at atmospheric pressures and red heats a positive charge was produced upon the plate, of the order of a few volts. This potential increases until the wire is at a yellow heat. As the wire gets hotter the potential decreases, until at a bright white heat the potential of the plate is very slight. Diminishing air pressure has but slight effect upon the plate potential until very high exhaustions are reached, when this potential begins to diminish and may even change sign, and as the exhaustion proceeds may reach a very large negative value. This pressure where the plate charge changes sign depends upon the temperature of the filament, being higher at higher temperatures.

Long-continued heating and expulsion of gas from the incandescent metal play a considerable part in the electrical phenomena. Long-continued incandescence favors the negative electrification of the plate. The presence of oxygen aids in the carrying off of a negative charge, thus producing negative electrification around the wire; hence the action of oxide of metal on filaments tends to increase the discharge of negative electricity. But oxygen also hastens the disintegration of the filament.

Gases which are dissociated by heat conduct on quite a different scale from those like air, hydrogen, or nitrogen. Examples of such are the vapors of iodine, bromine, chlorine, potassium, etc. These furnish a much larger supply of ions than the others. This dissociation occurs chiefly where the gas is in contact with the glowing electrodes. Of the metals, sodium and potassium have the highest conductivity under the above conditions, for the emission of negatively electrified corpuscles from sodium atoms occurs even at low temperatures; and I have used carbon filaments coated with a potassium compound. The conductivity of cold mercury vapor does not seem greater than that of air.

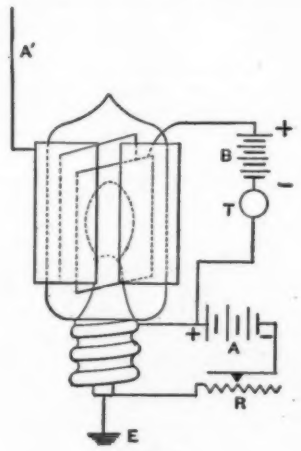

FIG. 5.

With hydrogen, the plate becomes negatively electrified even at atmospheric pressure; and when the filament is carbon instead of platinum the electrification on the plate is always negative. This means that the gas will discharge the plate if positively electrified; that is, a positive current will pass from the plate to the filament in the gas.

The electrification produced in the neighborhood of an incandescent wire is a complicated effect; it depends on the temperature and nature of the filament, and on the nature and pressure of the gas. It furthermore depends upon the electric and magnetic forces to which the vessel is subjected; and I have found that the shape and area of the plate or plates, the condition of its surface and edges, as well as its distance from the filament, are very important factors.

If the metal plate be connected by an outside wire to the positive terminal of the hot filament, a leak-current from the plate to the filament through the gas will be set up, as Elster and Geitel first found, passing mainly to that portion of the filament near its negative terminal. If the resistance of the lamp filament and the lamp's voltage be high, a very considerable leak current may thus be set up.

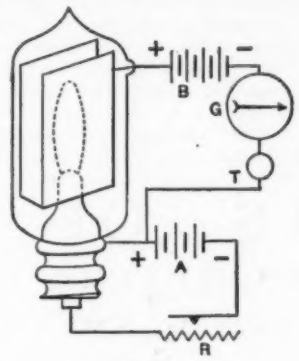

FIG. 4.

A battery of from three to eighteen dry cells is connected between the positive end of the filament and the platinum plate *W*, the latter being connected to the positive pole. The saturation current increases rapidly with the heating current through the filament, which also increases the velocity of the negative ions, as does also an increase in the applied electromotive force between plate and filament.

The rate of discharge of negative electricity from glowing carbon greatly exceeds that from platinum, while that from tantalum and other of the newer filaments, given the same heating current, surpasses the rate of discharge from carbon.

Thomson states the equation connecting the saturation current with the temperature as

$$\left(I = A\theta^{\frac{1}{2}}e^{-\frac{b}{\theta}}\right)$$

where θ is the absolute temperature, A and b are constants.

At 2,000 deg. C. this rate of emission from a platinum wire in high vacuo amounts to 0.1 ampere per square centimeter of hot surface. For carbon this current can equal several amperes per square centimeter surface. In the audion the flux current ordinarily ranges from 1 to 5 milliamperes.

The metal dust, or even vapor, from the incandescent filament may play a part in the phenomena, but not a controlling one. Thomson has shown that the value of e/m for the carriers of electricity in the type of exhausted vessel described is the same as its value for the carriers of the negative electricity in the cathode rays, or in the discharge of negative electricity from metals illuminated by ultra-violet light. In fact, in many ways the behavior of the audion, notwithstanding the extremely low potentials used, is very similar to that of a cathode-ray tube; and in one or two small pea lamps where the anode disk was close to the bend of the filament I have actually obtained, at only 22 volts, a blue-white beam of light playing between the filament cathode and the anode. Upon the approach of a powerful magnet this beam could be concentrated and deflected. A great increase in the current through the telephone marked the formation of this beam, and a violent hissing or squealing sound began when the magnet was approached.

The corpuscles at the filament are attracted by the metal of the filament, and to escape into the surrounding space they must be given sufficient kinetic energy to carry them through the surface layer where this attraction for the carriers is appreciable. Thus, as the temperature of the filament increases, a larger number of the carriers can escape from the wire. But the saturation values of the flux current do not depend upon the velocity of the ions, but only upon the number of ions produced in unit time at the surface of the hot metal.

The source of ionization is confined to the gas immediately surrounding the filament. The velocity of the ion at any instant is dependent on its distance from the filament, because the temperature is not uniform between filament and plate. The ratio of the velocities of negative to positive ions varies greatly with the temperature: thus they are given as 1,000 to 62 at 2,000 deg.

This fact explains why the positive conductivity of the gas in the vessel is almost entirely from the cold to the hot electrode in the gas, and not in the reverse direction; and why this unidirectional quality is more marked for higher temperatures of the cathode, the anode being kept cold.

In the form of audion illustrated in Fig. 4, I employ two platinum wings parallel to the plane of the bowed filament and about 2 millimeters on either side of it. These wings are soon coated with an iridescent deposit from the metal filament, especially at the portions opposite to the negative half of the filament. They become quite hot at this short distance, but not sufficiently hot to take part in the ionization of the gas.

When connected in the oscillation circuit as shown, properly attuned to the receiving electromagnetic impulse from the antenna, the audion under proper adjustment of heating current and battery *B* potential is extremely sensitive, giving response in the receiving telephone several times as loud as any other form of wireless receiver when subjected to the same impulses. It is, however, less sensitive to atmospheric or static disturbances, which are strongly damped or aperiodic.

I find the device extremely closely tuned with the syntonizer, for its operation seems to be dependent upon the sum total of the energy received from the complete wave train rather than upon the maximum first impulse of the train. In other words, while instantaneous as far as our senses or instruments can perceive, its action is sufficiently sluggish to be determined by the additive effect of the entire received electro-radiant energy through a short time interval.

When the filament is first lighted, an appreciable interval, about one-quarter second, elapses before the full sensitiveness is established. Before the flux reaches a steady state there is a period during which the number of ions is steadily increasing. As a result of the colliding of the initial ions with the gas molecules the number of ions and the current rapidly increase, until an equilibrium is finally attained.

The audion, to a greater extent than any other responder, is self-tuned. I mean that by regulating the heating current, the potential between wing and filament, or the distance between these, the audion can be made to a great extent selective *per se* to certain received impulses. And the determining factor here is not merely the frequency of the electrical oscillation; the spark frequency, or factors determining the total amount of energy received during a very brief unit of time, determine to an extent the amount of its response. Thus with 12 volts across it, it may give a loud response to a transmitter *A;* and with 10 volts "bring in" another transmitter *B* to the almost complete exclusion of *A*, although *A* and *B* are of equal power and of approximately the same wave-length, but differing considerably in spark frequency. Similar discrimination can be produced by adjustments of the heat of the filament, which also governs the amount of flux through the gas.

This flux is generally reduced when the audion is placed in a strong magnetic field, especially when the lines of force pass through the gas parallel to the plane of the wings, at right angles to the electric field. By this means also a tuning can be effected.

Again, it is not necessary to connect the anode to a terminal of the oscillating circuit. One terminal may be attached to a metal sheath or ring surrounding the glass vessel, thus forming a condenser with the filament or the conducting gas within the tube. In this case the adjustment of the syntonizer is generally different from that required for the same oscillation frequency, when the interior wing is directly connected in the oscillation circuit. In this condenser arrangement also the sound heard in the telephone changes its quality to an extraordinary degree, being of a dull muffled nature rather than sharp and staccato. Signals of this quality are sometimes much more readily distinguished from the "static" disturbances which so frequently render wireless signals difficult to read. The operator has thus a ready means of changing the quality of the received signals to suit the conditions.

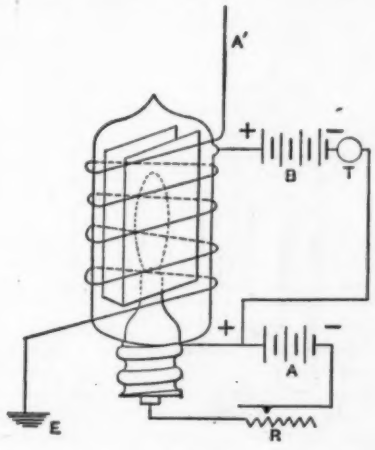

FIG. 6.

* Elster and Geitel, Wied. Ann., xvi., 1882.

This latter type of audion is the one I have found most serviceable in practice.

The audion may even be placed in the space between two plates of an air condenser in the oscillating circuit. A flat-walled type of tube is preferred for this arrangement. Again, the electrical oscillation may be led through a coil of wire wound around the outside of the tube (Fig. 6), and not through the audion at all, or through a flat coil brought up close to the tube, with its axis perpendicular to the filament. In this arrangement it is chiefly the electromagnetic component of the passing oscillation which affects the motion of the ions within the vessel. The ions are readily influenced by a magnetic field.

By shifting the syntonizer connections from the wings to this helix, I have been able to cut out completely signals from a transmitting station so near as to baffle all attempts with the ordinary tuner methods, and to bring in other relatively faint signals.

The audion has the further advantage of entire absence of adjustment in the receiver itself. It gives no evidence of fatigue under any conditions of use. Furthermore, it requires no protection from the violent impulses of the transmitter at its own station, whereas the sensitiveness of the electrolytic receiver is completely destroyed by one such violent impulse, unless its small electrode is protected by a shunting switch.

I have arrived as yet at no completely satisfactory theory as to the exact means by which the high-frequency oscillations affect so markedly the behavior of an ionized gas. Fleming points out that when the cold plate of the Elster-Geitel tube is connected to the positive end of the filament, and the two put in a high-frequency oscillation circuit, only the positive half of the oscillation can pass from the plate to the filament across the gas. He uses this principle to rectify the Hertzian oscillations, and applies the unidirectional currents of the oscillations themselves to operate a sensitive galvanometer, or direct-current instrument, for quantitative measurements over short distances.

When an independent external source of electromotive force is applied, in the manner I have described, the action becomes quite different. It then operates as *relay* to the Hertzian energy instead of merely rectifying this energy so that it can be used directly to give the sense signal.

The audion, therefore, is tremendously more sensitive and available in practical wireless. A sensitive direct-current instrument in the *B* circuit shows a steady deflection varying not a whit, by increase or decrease, during the reception of strong "wireless" signals. An electrolytic receiver or "polariphone" under similar conditions would cause a great deviation in the deflection of a milliammeter, although the signals in the telephone with the electrolytic are not so loud as with the audion.

I have connected two audions in series in opposition in the oscillating circuit, each with its separate heating circuit, and still heard the signals in the telephone connected to the second audion equally well, whether the wing in the first be connected to the wing or to the filament of the second.

When one of the tubes is unlighted, or if lighted its *B* circuit is open, no high-frequency impulses pass through it unless the wing and filament are very close together. When cold it acts merely as a condenser whose armatures are the wings and filament and whose capacity is extremely small.

(To be continued.)

THE EUCALYPTS OF AUSTRALIA.—I.*

RECENT WORK ON THE EUCALYPTS.

BY HENRY G. SMITH, F.C.S.

IN certain districts in America considerable activity prevails at the present time in the planting of Eucalyptus trees, the idea being, primarily, to supply hardwood for railways and for other works of construction. This too is the case in South Africa, where extensive planting of eucalyptus trees has also taken place. In India, Algeria, Italy and other places the eucalypts have been cultivated, and with very great advantage to those countries in many directions. When the results of these plantations become better known and the advantages appreciated, it may be assumed that increased activity will prevail in the establishment of eucalyptus forests in other countries.

The distillation of essential oils for medicinal purposes, for perfumery, and other economic requirements for which the several oils may be found suitable, will of a surety be extended. It may also be expected that the possibilities of certain species for producing a bark of excellent quality for tanning purposes will not be overlooked, so that we may soon expect to see the cultivation of special species for special products greatly extended.

The scientific knowledge concerning the products of the several species of Eucalypts, which has been obtained during the last few years, has placed the question on a much more satisfactory footing than was previously possible, and it is now generally known from which species the most satisfactory results can be obtained in the direction required.

The great chemical fact underlying this question, is that of the comparative constancy of the products of any particular species, so that the study of the possible economics of the several members of this great genus is provided with a sure basis.

There are certainly not less than 200 well defined species of eucalyptus in Australia, the greater number of which have been chemically investigated.

At the present time, beyond a few of the more common species, but little is known by the general public of the economic possibilities of the members of this group of trees, and it is largely for this reason that *Eucalyptus globulus* has obtained such wide prominence in different parts of the world. It has been stated that even to-day many of the seedsmen in America know no other species. In California, this species has, in years gone by, been planted in large quantities.

Recent investigations, however, have given *Eucalyptus globulus* its proper place in the sequence of species. One cultivator in America has at the present time 900,000 eucalyptus trees in his forests, and not a single tree of *E. globulus*. He considers that his trees will soon be worth $2.50 each or even more. Australia might well take a lesson from such an enterprise, and profit from its results.

I shall refer as briefly as possible to botanical questions, restricting myself more fully to the chemical side, but it will be seen that the chemical and botanical studies of these trees are inseparable, and it is to the phyto-chemical researches which have recently been undertaken that the discovery of several important facts is due.

The name Eucalyptus was given to the genus by L'Héritier in 1788 in allusion to the presence of the lid or operculum of the bud stage. The numerous species, into which it has been considered advisable by botanists to divide the genus, have suggested to some workers the idea that hybridism has played an important part in the formation of these numerous species. There is much to be said in support of this theory, but the weight of chemical evidence is dead against it, if we admit the peculiarities of the parent being passed on to the offspring. From the results obtained during recent researches it was evident that the theory of evolution accounted for the formation of the numerous species better than any other, and it has been possible to formulate a genealogical table to illustrate this process of evolution, and to show how the genus has developed through past ages. Haeckel says that the careful construction of these genealogical trees is not an amusement, but the chief task of modern classification.

In Australia gigantic eucalyptus trees occur, and one growing at Marysville in Victoria has a circumference of 70 feet, and is about 150 feet to the first branch. This particular tree is probably some 2,000 years old, yet the venation of the leaf is that of the phellandrene group, the most recent of all the eucalypts; so that this tree (probably *E. regnans*) belongs only to a species of to-day. When we consider the length of time necessary for any species to distribute itself over a large extent of territory, after it has become well established, we can begin to understand the constancy in the members of this genus, and to feel that time has been the chief factor in their establishment.

The eucalypts are essentially oil yielding plants, and the known constituents of the several oils number about thirty. Although the known constituents are so numerous, yet they do not all occur in the product of any one species. There is, however, a remarkable regularity in their distribution, and the commencement and increment of at any rate the principal constituents are well marked and most clearly indicated by the remarkable and characteristic feature of alteration in the venation of the lanceolate leaves. It is now clearly understood that the venation of the leaves of most species is indicative of certain oil constituents, and this changing of leaf venation has been contemporaneous with the alteration in the character of the oil. It has been possible to show this venation by photography directly from the natural leaves themselves, using the leaf as a negative. This very well demonstrates the evolutionary processes which have taken place and suggests that there is a natural arrangement governing the peculiarities and properties of eucalyptus trees, which will be better defined when better understood.

In what may be considered the earliest members of the genus the oil consists largely of the terpene pinene, with an entire absence of eucalyptol and phellandrene; the leaf venation illustrating this resembles the markings in a feather, the midrib is thick, and the marginal vein close to the edge of the leaf. As eucalyptol makes its appearance in the oil the midrib becomes less stout, the marginal vein recedes from the edge, and the structure of the leaf has a cellular appearance, thus allowing more room for the oil glands. In the leaves of those species giving an oil with a maximum amount of eucalyptol these characters are intensified. In the groups from which phellandrene oils are obtained, the venation is again different, the midrib is very thin, there is an entire absence of the feather-like venation, the veins are quite acute and lace-like, and the marginal vein has become so far removed from the edge of the leaf, that often a secondary one has formed. The genus thus divides itself roughly into three main groups, governed by the venation of the leaf, and this venation is characteristic of the chief constituents in the oils.

It is evident, therefore, that all eucalyptus oil cannot have the same medicinal value. At present, one of the chief uses for eucalyptus oils is for pharmaceutical purposes, and it thus becomes necessary to know from which species the chief constituents can be obtained most satisfactorily, and in greatest abundance. The bactericidal value of the several constituents found in eucalyptus oils has been investigated by Dr. Hall of Parramatta, whose work represents a considerable addition to our knowledge in this respect. The new constituents recently discovered were also included in that investigation.

Although recognizing the importance to Australia in the preparation of oils for pharmaceutical purposes, which industry at the present time has a money value of from $200,000 to $250,000 annually, yet, it is to the manufacturing industries that Australia must look for the development and utilization of the enormous supplies of raw material at present going to waste. It is possible that by systematic effort Australia could, from her eucalypts, largely supply the demands of the world for oils useful for many solvent purposes, as well as for other uses in the arts and manufactures, and supply oils also for perfumery, for scenting soaps, and for flavoring purposes, but to be successful the industry must be systematized and governed by the results of scientific investigation. A very large proportion of eucalyptus species being useless for economic purposes, these might be eradicated and their places taken by useful species.

Two economic facts of great importance stand out prominently; these are: (1) that the young growth of any species yields an oil corresponding in constituents to that of the mature trees and often having a larger yield of oil, and (2) that most eucalypts are very tenacious of life and when cut down soon throw out fresh growth. If then large tracts of country were devoted to the growth of any particular species yielding the required oil, and when sufficiently grown cut down by machinery, and distilled in correspondingly large stills, the cost of production would be merely nominal. With the old methods of distillation, using the 400-gallon ship tanks, the oil from some species of eucalyptus has been distilled for from 75 cents to 90 cents per gallon. This is the case with several species giving terpene oils. The possibility of success in this direction, therefore, when treated on a sufficiently large scale, seems to be considerable. One of the principal factors in this connection, is that of yield of oil obtainable from any species. The variation in yield is very great, but the yield from most species is now known and is practically constant. With the perfumery oils this factor has perhaps less commercial importance.

The oil from *Eucalyptus Macarthuri* contains a large amount of the alcohol geraniol, principally as an acetic-acid ester, and it thus has commercial value for perfumery purposes. From a very large number of determinations the ester has been found to range from 60 to 75 per cent in oil from mature trees, when distilled at various times of the year, so that a minimum of 60 per cent of ester might very well be made the standard for the oil of this species. Experiment has shown that when the larger amount of ester is present, the free geraniol has considerably diminished, only 6 per cent of free alcohol being present when the ester reached 75 per cent, whereas 10 per cent was shown to be present when the amount of ester was only 60 per cent. The oil from *E. Macarthuri* never contains eucalyptol, nor has phellandrene ever been detected, so that if a minimum of 60 per cent of ester is insisted upon, sophistication of the oil is hardly

* Abstract from the Journal of the Society of Chemical Industry.

possible. The whole of the ester in this oil is saponified in the cold, by two hours' contact, using alcoholic potash, and the quantitative results are certain. The following results were obtained from two samples of the oil of this species: (1) Ester before acetylating, 63.7 per cent; after acetylating, 85.2 per cent. (2) Ester before acetylating, 71.68 per cent; after acetylating, 80.5 per cent. After distilling *in vacuo*, No. 2 gave 73.95 per cent of ester, and after acetylating, 82.2 per cent.

The well ascertained fact that the oil obtainable from the young growth of all eucalyptus species is the same in character as that obtained from mature trees is also borne out with the "suckers"* from this tree, and fortunately the yield of oil is greater also, 0.23 per cent of oil being obtainable from "suckers." The oil from the young growth should be easily obtained, and in any quantity. There seems no reason, therefore, why this plant should not be cultivated for its oil, and when sufficiently grown it might be cut down by machinery. If sufficiently large stills were utilized the oil should be obtainable at a comparatively low price. The value of the oil of this species, containing 80 per cent ester, has been considered to be $6 per pound, but it should be possible to produce it at a considerably cheaper rate. As it has been shown that the eucalyptus are very tenacious of life, destruction of the plants should not take place if the material were collected as suggested, and at the proper time of the year. Experiments should also be carried out to determine the most suitable time for collecting the material, so that a maximum yield of oil might also be obtained.

Another eucalyptus which may eventually be of considerable economic value as an oil yielding plant, is *E. Staigeriana*. Although it has not been possible, as yet, to carry out conclusive experiments with this tree, there is no reason to suppose but that this species will follow the rules always found to be constant with the members of this genus. The yield of oil from mature leaves is large, 2.5 per cent, and would be greater from the young growth. The oil of this species may eventually be used as a flavoring agent, and take the place of lemon oil for many purposes. The principal difference between this oil and lemon oil is that the predominant terpene of the oil of *E. Staigeriana* is lævo-limonene, while that of lemon oil is dextro-limonene.

The odor of the oil is very aromatic, reminding much of lemon oil, and has no resemblance to ordinary eucalyptus oil. The greater yield of citral over that of lemon oil is also worthy of notice, particularly if the manufacture of "terpeneless oils" is undertaken.

One wonders, perhaps, why Australia does not take advantage of the possibilities of these unique species of eucalyptus, by utilizing some waste places for their cultivation, and by modern commercial methods building up an industry with their products, and so utilizing some of the resources of the continent in new ways.

The oil from *Eucalyptus citriodora* consists principally of the aldehyde citronellal, and if the production of the oil is cheapened, it should have considerable value for scenting soap and other manufacturing purposes. The cost of collecting leaves from mature trees militates at present against cheap distillation, and as the yield of oil is not large (0.58 per cent) it is to the production from cultivated material that we must look for the successful exploitation of this species as an oil producing tree. The amount of aldehydes present in the oil—mostly citronellal—averages about 90 per cent.

This tree is a very good illustration of the comparative constancy of the products obtainable from particular species of eucalyptus, because no matter where the tree is grown its oil is practically constant in composition and character. Numerous illustrations of this fact have been accumulated from different species, as it was felt that this factor was of the greatest importance commercially. It is found that the constituents vary only slightly among themselves, so that when the results from any particular species have been accurately determined from undoubted material, it is known what material is obtainable from that particular species. One will not obtain a phellandrene oil from such species as *E. Smithii* or *E. globulus*, nor eucalyptol in quantity from such species as *E. dives* or *E. radiata*. Each has its own peculiarities, and if any particular constituent is required, then the species which contains that constituent in greatest abundance must be exploited.

The eucalyptol bearing species are the most numerous, as this constituent occurs, in either small or large amounts, in the oils from most eucalypts. It is even found in small quantity in the oil from *E. dives*, it occurs in the pinene oils, and also in the phellandrene oils, as in *E. risdoni* and in *E. amygdalina*, etc. Provided a sufficient amount of eucalyptol is present—the minimum might well be fixed at 55 per cent—the presence of a small amount of phellandrene in oils for pharmaceutical purposes should not be condemned any more than pinene. It is true that the oils richest in eucalyptol are not obtained from the phellandrene bearing plants, but it must not be forgotten that we do not even now know which is the most efficacious medicinal constituent in eucalyptus oils. In the preparation of eucalyptol oils for pharmaceutical purposes commercial requirements will settle the matter of species, and the price of the article will eventually find its natural level. The two factors to be considered are percentage of eucalyptol and yield of oil. The increased cost of collecting leaves from large trees, over that of the shrubby forms or Mallees, practically puts the large trees out of the running; so that if it is desired to utilize these species, they will have to be cultivated, to place them on an equal footing with the shrubby forms.

A consideration worthy of notice when dealing with the distillation of the eucalyptol oils for pharmaceutical purposes, is the duration of time necessary to distill the leaves, so that the best results may be obtained, both in amount of oil distilled and in the quality of the product. An investigation was undertaken to decide this point, and it was found that with *E. amygdalina* 89 per cent of the total oil distilling came over during the first 2 hours, 7 per cent during the third hour, and 4 per cent during the fourth hour. Practically the whole of the eucalyptol came over during the first two hours, the less volatile constituents as the sesquiterpene, aromadendral, etc., distilled far more slowly. It is thus possible to leave the greater portion of these products in the still, securing a superior eucalyptol oil by so doing. Practically the same results are obtainable with other eucalyptol bearing species.

These high boiling constituents have some value, however, in raising the specific gravity of the oil, but it is doubtful whether economy of fuel, time, and labor is not better served by stopping the distillation after two or two and one-half hours. Of course this method is not applicable to the perfumery oils, as with these it is necessary to obtain all the available oil from the leaves.

It may be well here to refer to the method of eucalyptol determination. The phosphoric acid method for the determination of eucalyptol in eucalyptus oils was discovered by L. R. Scammell, of Adelaide, South Australia, in 1892, and the method was utilized for the commercial manufacture of eucalyptol. In 1894 the method was patented in England, France, Germany, and America, as well as in the Australian Colonies, as a commercial process for the production of eucalyptol. It has now been supplanted by the freezing process, but it still remains the most useful method for the quantitative determination of eucalyptol in essential oils, though it is not a perfect method for general practice, as so much depends on the mode of manipulation and on the analyst. If a method could be devised which would minimize these errors of manipulation, it would be a most welcome acquisition.

When the cake formed by the combination of eucalyptol with phosphoric acid has been prepared in a perfectly dry condition, it can be weighed for the determination of the percentage amount of eucalyptol, or if preferred decomposed by hot water and the eucalyptol measured, or it may be prepared in petroleum ether as recommended in the American Pharmacopœia, although the dry method is preferable.

Taking varying amounts of the solid cake, prepared with the greatest care and decomposing with hot water, the mean of six determinations gave weights of eucalyptol corresponding to a mean value of 59.47 per cent (59.34 to 59.57) and the weights of the phosphoric acid which had entered into combination, determined by titration and other methods, represented an acid containing 89.28 per cent H_3PO_4. The phosphoric acid used in the determination contained 89.4 per cent H_3PO_4. One might expect, too, that the water separating from the H_3PO_4 in the formation of the eucalyptol phosphate, if such separation took place, would prevent satisfactory quantitative results being obtained. Experiments were made with more dilute phosphoric acid, but the resultts were not at all satisfactory.

Although several organic acids have been determined in eucalyptus oils, yet, they all appear to be in a state of combination as esters, with the exception of a portion of the acetic acid. Efforts were made to determine whether the lower members of the aliphatic monohydric alcohols were present in any particular eucalyptus oil, and if so which of them. The investigation was made on half a gallon of the water which first distilled when the oil of *E. amygdalina* was rectified. The results showed that methyl, ethyl, isobutyl, and amyl alcohols were present, and in somewhat considerable amount. It was thus possible to chemically prove the presence of all of them in the oil of this species. It is not to be supposed, however, that they all occur together in the oils of all the species, although they may be present even in traces.

Both ethyl and amyl alcohols and formic acid had previously been detected in a eucalyptus oil. It seems thus conclusive that the presence of the known aldehydes and acids in these oils is traceable to the prior presence of the corresponding alcohols.

The presence of esters in eucalyptus oils is often large, and one or other of these appear to be present in all eucalyptus oils, from traces up to 77 per cent. In some of these oils a valeric acid ester occurs; the oil of *E. saligna* was found to be the best in which to determine its presence. The amyl ester of eudesmic acid occurs in small amount in the oil of this species, but valeric acid is also found existing as an ester, and was separated in sufficient quantity to chemically determine its identity. No other alcohol than amyl alcohol could be detected in the oil of this species. It may be mentioned that those oils in which this valeric acid ester occurs contain most markedly the corresponding aldehyde.

Other constituents worthy of mention which are found occurring in eucalyptus oils are—eudesmol, the stearoptene; aromadendral, the aromatic aldehyde; piperitone, the aromatic ketone; and the sesquiterpene. Eudesmol has been found in a considerable number of eucalyptus oils, and one species, previously undescribed, was named by R. T. Baker, *E. camphora*, from the presence of this stearoptene in the oil. This is not the only eucalyptus that has been so honored. The "Sydney peppermint," *E. piperita*, derives both its vernacular name and its scientific name from the presence of piperitone in its oil, although this constituent was not known until recently. It is the presence of this ketone that causes the name "Peppermint" to be applied to a large group of these trees. It is not perhaps generally known that eucalyptus oil was one of the first Australian products exported to England, and a quart of the oil distilled from the leaves of the "Sydney peppermint" was sent to a Mr. Wilson in 1788, soon after the first settlement in New South Wales was formed. Dr. White mentions that he found this oil most efficacious in dealing with some of the ailments of the convicts at that time.

Aromadendral is a frequent constituent in eucalyptus oils, being found in all the members of the large group of trees known as "boxes," as well as in allied species; and is found mostly in those species in which phellandrene is absent. It is to the presence of aromadendral, therefore, that the lævorotation of the "box" oils is due.

In some species dextro-rotatory, and in others lævo-rotatory, pinene occurs in such abundance that the oils are practically turpentine oils, so that it is hardly possible to detect sophistication with ordinary turpentine. It is thus necessary to insist on standards which will insure the quality of the product required, but any general standard cannot meet all requirements, nor determine the value of eucalyptus oils for all purposes. For pharmaceutical oils the specific gravity should be 0.91 at 15 deg. C. (59 deg. F.) or 0.905 at 22 deg. C. (71.6 deg. F.) but the figure can be readily calculated from any ordinary temperature, because it has been determined that these oils alter their specific gravity 0.00075 for every ordinary degree of temperature Centigrade.

There is no more interesting chemical group of substances in the eucalypts than the astringent exudations, or kinos. Many of the species exude kino freely, but these differ very greatly in chemical constitution. Whatever is eventually done with eucalyptus exudations commercially, it must be recognized that it is just as imperative for the product of a particular species or groups to be kept distinct, as it is in the preparation of the various oils. The two main uses to which these exudations may eventually be put, is in the tanning industry and for pharmaceutical purposes, principally for the preparation of tinctures.

(To be continued.)

* Eucalyptus species do not sucker in the strict sense of the term, and the word is here used with that understanding to denote adventitious shoots.

BIRDS THAT KILL SNAKES.*

By W. G. FITZGERALD.

"Or what use are snakes?" is a question often asked by the student of Nature. They do not gratify the esthetic sense, as other useless creatures do, but are loathsome and pernicious, and altogether a mistake. Surely they are one of Nature's abortions or failures? Every other created thing views them with horror—men and monkeys, beasts of prey, and reptiles, and birds. Not to mention the owls, kites, carrion crows, and ravens, which all have a bitter antipathy to the ophidian race and kill them whenever found. Even though they may not always devour the mangled remains, there are hosts of birds who gain their livelihood by assiduously seeking poisonous serpents.

Ask the Australian colonist which of the many queer birds that adorn his primitive forests he holds in most reverence, and he will instantly name the "laughing jackass," as he calls the giant kingfisher (*Dacelo gigantea*). Its note does certainly resemble a donkey's bray. The dacelo lives almost entirely on poisonous reptiles, in which the island continent is inconveniently rich. And he varies the diet only by lizards—especially venomous ones; also frogs and toads, cicades, and tree leeches. He never catches fish after the man-

* From American Homes and Gardens. Published by Munn & Co.

ner of his American or European kindred. I have seen one of these singular birds catch a deadly snake.

It was a hot day in the Blue Mountains of New South Wales, and I had been tramping through almost shadeless bush for some hours. At last, reaching a big mimosa, I sat in its shadow on a fallen tree trunk; for it is almost the only one of the Australian trees that does not turn the edge of its leaves to the sun; this accounts for the curious shadelessness of the antipodean bush. Suddenly I beheld a big dacelo in one of the gum trees opposite. He was sitting motionless, as I had seen his American namesake over pond or trout stream.

He startled me with an abrupt dash to the ground not far from where I sat, and a few seconds later flew back to his perch with something wriggling in his big fierce-looking bill. It was a carpet snake that had been basking in the hot sunshine just beyond the shelter of the mimosa clump. The dacelo had seized the reptile by the neck and held it in a vise-like grip, despite its violent struggles and writhings. And now and then the angry bird would bang its prey's head against the hard bough of the gum tree until he had reduced the evil-looking deadly thing to mere harmless pulp. Then only did he relax his hold, to toss the dead snake, limp and lifeless like a strip of hide, high into the air.

Very cleverly did the bird catch it by the tail, and proceed to engulf it in its capacious maw. The coiled-up remains of the reptile formed a projecting mass on the bird's breast that was fully visible from where I sat. So far the jackass had been too busy capturing and preparing the snake to notice me, though I sat within ten yards of him. His banquet done, however, he caught sight of me, ruffled up his feathers fiercely, and with an eerie shriek compounded of laugh, groan, and bray, flew off noisily to digest his capture.

As the intestinal tract of the dacelo is short, digestion is not a lengthy process. Consequently he eats often, and from dawn to dusk is industriously after snakes, being on that account first favorite of the woods with squatter and bushman, who protect the bird from every pot hunter.

The Australian magpie or singing crow is also a serpent killer, as is the native crane and several others. This crow, handsome, lively, and clever, is known from Sydney to Fremantle for his black and white coat and startling diet of centipedes, scorpions, and poisonous snakes. He, too, first kills his prey, throws it into the air with a song of triumph and then disposes of it at leisure.

The "native companion," as the Australian crane is called, is no mean antagonist of the ophidian race, of which it destroys hundreds of thousands. Its method of killing is peculiar, for it stamps on the reptile with the full force of its leg, retracted up to the body and then propelled downward like a piston rod with all the bird's strength on foe and prey. And to make assurance doubly sure the crane strikes a quick succession of blows that crushes the last vestige of life out of the mangled reptile, which is then swallowed with no more ado.

I fear the natural history books of one's childhood are very far astray when dealing with another snake-eater, the secretary bird of South Africa (*Sepentarius reptilivorous*). More than once I have seen this curious creature—half vulture and half falcon, with a suggestion of the crane—tackling a big snake just as the native companion of Australia does; that is to say, never touching it with beak or wing, but always stamping on the squirming folds with its powerful legs, disabling the reptile at the first blow and finally dislocating all the vertebræ.

Should the snake show fight, the secretary bird seems to tighten all its feathers about it; hopping briskly here and there, with all the "foot-work" of the veteran pugilist, so as to avoid the desperate onslaught. Such contests can only end one way, and the crushed serpent is soon reposing harmlessly in its living tomb. Another Australian bird, known as Jardine's harrier, is a serpent killer of great ability, especially endowed by Nature with legs of great length mailed with strong yellow scales, quite impervious to ophidian teeth. It also kills and eats frogs, newts, lizards, and other reptiles.

The harrier, besides the pied crow and the laughing jackass, is of great value to Australia, which contains so many varieties of deadly snakes. It seeks for them on the wing, hawking at no great distance from the ground over the hot and stony places frequented by them. With a sudden sweep the reptile is grasped by the neck with one powerful foot, and then the harrier soars high into the air and kills its reptile prey by dropping it on rocks or hard sun-baked earth from great altitudes.

The Indian adjutants and cranes of all kinds, Manchurian and Dutch, are also snake hunters. Indeed, in India the adjutant is treated with as much consideration as the sacred monkeys of Hanuman, and woe betide the inexperienced tourist or visitor who tries to shoot one of these curious birds.

Then there is the burrowing owl of the South American pampas, who preys upon young rattlesnakes, following the creatures into their own holes. These birds also are respected, and with cause. For there is no greater foe to all warm-blooded mammals than the poisonous snake; and any bird with cleverness and courage enough to kill one and dine off it afterward, well deserves our gratitude and protection.

SCIENCE NOTES.

Prof. Rudolf Emmerich, Professor of Hygiene in the University of Munich, announces the discovery of a cure for diphtheria, effective even in the most dangerous cases. He calls the serum "pyocyanase," producing it from the assimilation of the pyocyanase bacilli developed in liquid cultures. The preparation is sprayed into the patient's throat, completely destroying the diphtheria bacilli.

The use of artificial graphite is on the increase. The quantity manufactured in 1906 amounted to 5,074,757 pounds, valued at $337,204, which is the largest quantity produced in any year since its first introduction in 1897. Of the total output 2,766,000 pounds were ground to a fine powder and this product was valued at $94,578. A process has recently been developed for treating artificial graphite with tannin. The resulting deflocculated graphite is claimed to be adapted especially for use in lubrication, with either water or oil as a vehicle.

In a paper read before the Academy of Sciences on Prof. Bordas's discoveries, based on the observation of the late Prof. Curie that glass acted upon by radium acquires a magnificent azure tint, it was stated that Prof. Bordas placed a small quantity of corundum in contact with radium for a period of a month. At the end of the time, he found that uncolored corundum acquired the yellow of the topaz, blue corundum became an emerald green color, while violet corundum took a sapphire blue. Corundum is an oxide of aluminium, and when colored is known as sapphire, Oriental ruby, Oriental topaz, and Oriental amethyst, according to the tint. The granular variety of corundum is known as emery. Upon returning the colored samples to the jeweler from whom he bought them, the former gave the value of the altered specimens as $9 a carat. Upon repeating the experiment with various shades of the mineral, one that became ruby colored was appraised by the jeweler at from $100 to $160 a carat. The altered substance was not affected either by heat or by electricity.

Through the generosity of Mr. Emerson McMillin a fine collection of heads and horns of native animals has been brought to the United States. The collection was formed by Mr. A. S. Reed, an Englishman. During the years when big moose and caribou were abundant on the Kenai Peninsula, and in other accessible districts of Alaska, Mr. Reed, then residing in Victoria, made many hunting trips to the best game districts of Alaska and British Columbia. He spent several winters in the far Northwest, sometimes with the Indians, in order to hunt moose and caribou when they were in their finest condition as to antler, and to hunt the big brown bears when their pelage was at its best; in fact, Mr. Reed had his pick of the big game at the time when it was most plentiful, and the finest specimens taken by him were preserved. His collection, which includes heads and antlers of Alaskan moose, caribou, bear, sheep, and walrus, can never be duplicated. There is a moose head the antlers having a spread of 76 inches; a caribou head and a Kadiah bear skin said to be the finest specimen in the world; and other exceptional specimens. The collection was for sale for $10,000; when the owner heard that it was wanted for public display in New York he generously cut the price in half. The trophies are at present stored in the zoological park, and on the completion of the administration building there in 1908 will be displayed in it.

At the recent Congress of the French Association for the Advancement of Science, Prof. A. Henry demonstrated a process of using slaked lime to produce a high vacuum. Hydrated lime—Ca $(OH)_2$—as is well known, can be dissociated into anhydrous lime —CaO—and water. The tensions measured after two hours' heating will vary between 2.4 millimeters at 85 deg. C. and 20 millimeters at 145 deg. C. The vapor given off by the heated hydrate is used to expel the low-pressure air left in a receiver by an ordinary air or water pump. The receiver is connected on the one hand with a glass bulb containing about 30 grammes of slaked lime, and on the other by a vapor-absorbing tube with an ordinary air pump. The vacuum maintained by the air pump being about 1 centimeter, the temperature of the lime is raised to about 150 deg. C. by an alcohol lamp, when water vapor will be given off; after about four minutes' heating the receiver should be sealed on the side turned toward the air pump. The lime will soon absorb the water vapor left in the receiver, and the vacuum will become high enough to allow cathode rays to be produced. This is shown by providing the receiver with two electrodes, when a discharge from an induction coil will give a radiation susceptible of deflection under the action of a magnet. This tube, while connected to the lime bulb, can be used to show the variable aspect of discharges according to variations in tension by simply heating the bulb slightly with the alcohol lamp, when the various phenomena, including those of Geissler tubes, will be produced successively within about two minutes; by allowing the bulb to cool at the contact of the air, the same phenomena will be reproduced in inverse succession within less than five minutes. Long glass tubes, such as are used in connection with Tesla experiments, have been likewise treated according to the above process. All these experiments have been made with marble lime, while hydrated baryta under similar conditions also produces a vacuum giving off cathode rays. This cheap and quick process may prove highly valuable not only for the laboratory, but even for industrial purposes.

ENGINEERING NOTES.

The production of pig iron in Belgium during the eight months ending with August last comprised 732,470 tons of Bessemer and basic, 151,030 tons of forge pig, and 67,140 tons of foundry pig, a total of 950,640 tons, which contrasts with only 937,490 tons in the corresponding period of 1906.

It is stated that the Imperial Steel Works, near Shimonoseki, Japan, are about to submit their Siemens mild steel to a series of tests before Lloyds' surveyor at Nagasaki. The object is to have their name added to the list of approved firms which make steel to be used in the construction of ship and boiler materials for vessels classed at Lloyds. At the present time most of the structural steel used in shipbuilding in Japan comes from Great Britain.

A new automatic continuous ore-feeding reverberatory furnace consists of a fire-box and a hearth-chamber, whose angular side walls converge and meet in a point at the front end of the hearth. At this point, and on a level with the floor of the hearth, is provided a tap-hole or matte through the front wall of the furnace; at the back end of the hearth, and a little above the floor level, are placed tap-holes for the slag, on both sides of the fire-box. In the side walls of the furnace are placed a number of ore shoots terminating close to the floor of the hearth, and arranged so as to deliver ore continuously at both sides of the front end of the furnace as fast as the ore melts on the hearth of the latter.

It has been found that for maximum efficiency in a steam turbine it is requisite that the thickness of the elementary streams should, in the successive stages of progress through a multiple-effect turbine, vary approximately with the radius of curvature of the absolute path of the stream; so that with a radius of curvature of the absolute path of the stream becoming greater, the thickness may be increased by the employment of fewer vanes, or for a continuous thickness of stream by a constant space-interval or pitch of vanes, then a uniform radius of curvature of absolute path should be maintained by the use of vanes of diminishing radius of curvature. This action has been geometrically demonstrated, and a diagrammatic illustration given of the forms of stator and rotor vanes adopted.

In a recent issue of the Revue Scientifique Dr. C. Féry gives an illustrated account of the new methods of determining high temperatures in industrial operations. For temperatures up to 700 deg. C. he recommends a thermo-electric couple of iron-constantan, from that to 1,300 deg. C. one of platinum and its alloys, in each case in combination with a self-registering arrangement. Where the thermo-couple would be injured if brought into direct contact with the source of heat, he advocates the use of his own pyrometer, in which the radiation from the source is concentrated by a concave mirror on to the thermo-junction. For sources of small dimensions at temperatures above 900 deg. C., optical pyrometers, e. g., Wanner's, are the most useful.

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